SCIENTIFIC AMERICAN SUPPLEMENT, No. 976

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Scientific American Supplement, Vol. XXXVIII. No. 976
Scientific American, established 1845.

NEW YORK, SEPTEMBER 15, 1894.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE BRIDGE OF NIPHON-BASHI, YEDO, JAPAN.

YEDO is divided by its watercourses into several parts which are connected by bridges, that of Niphon-Bashi being the most notable. It is held to be the geographical center of the empire, and from it the distances to all other parts are officially reckoned. This bridge received its name of Niphon-Bashi because it stands at the head of the imperial carriage road that traverses the great island of Niphon, from its southern extremity, in front of the island of Kinshin, to the extreme northern end, in front of Hakodati, on the island of Yeso.

In our engraving the celebrated mountain Fusi-yama is seen at the left.

[NAUTICAL MAGAZINE.]

SEA SALTS AND CARBONATES.

By Rev. J. A. DEWE.

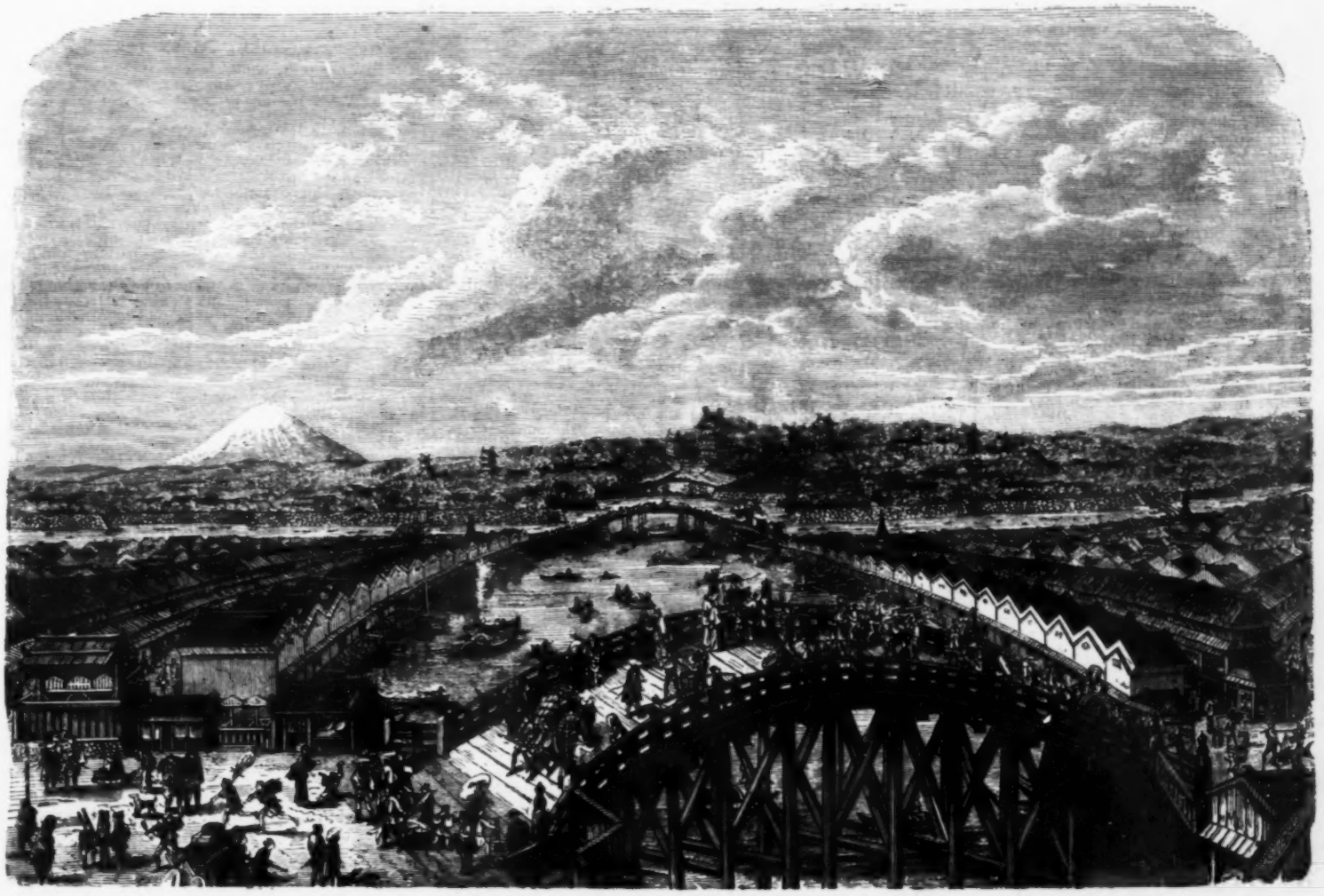
ONE of the most fundamental and universal laws that we see carried out in the creation and conservation of the universe is that of the interdependence of substances one upon the other. A most wise and sapient Being, in all His operations, follows what may be called the law of least means, never making use of means greater than are necessary for the end in view, and never displaying a useless amount of energy. As a consequence of this law, the beings and forces which constitute the great mass of the visible world are so constituted that one could not exist without the other, and all act and react in one continual circular progression.

The mutual dependence between sea and land, or rather between the elements that are necessary for the preservation both of one and the other, is in this view very worthy of consideration.

The two principal substances that sea water contains, which maintain it in its present condition, and render it not only a fit habitation for the finny life within it, but also an indispensable factor in the conservation and propagation even of terrestrial life, are carbonates and salts. Under these two headings all the other instances contained in the sea may be classified. The process that applies to one carbonate also applies in an equal manner and degree to all its other compounds, and what we have to say with regard to the ingress and consequent elimination of common salt, will also hold true with regard to the bromides, iodides, and chlorides which are also contained and stored up beneath the surface of the sea, though in smaller quantities. The first substance which is found dissolved in sea water is the carbonate. It is true that comparatively speaking its quantity is far inferior to that of the salts; but considered in itself, and in relation to the waters that contain it, its importance is of so great moment that without it the world would soon become but a stagnant waste, every spark of animal life would soon become extinct, and the whole economy of nature disturbed, and even destroyed altogether. The amount of carbonate contained in a tumbler of sea water may be small and insignificant indeed, barely exceeding even microscopic dimensions, but, when considered as pervading and permeating an immense sheet of water that occupies by far the greater portion of the surface of the globe, then its dimensions become almost fabulous, and quite exceed the limits of calculation. If we imagine vast continents rising out of the sea then we can form some idea of the vast quantity of carbonate that is found in the living deep.

The first question that arises is how it got there. Nature itself, if we use our faculties of observation, will supply us with the answer. If we take a small quantity of sea water and an equal amount of river water, and compare together the quantity of carbonate contained in both, we shall find that the ratio of the substance contained would be but as one to a thousand. But if we apply the same reasoning to the river carbonate as we did to that of the sea, and if we examine the quantity of carbonate that is poured by one river alone into the bosom of the sea in the course of the day, we shall find the amount to be truly enormous. A river of ordinary size, like the Thames, pours in a contribution of thousands of tons a day, other rivers of more considerable magnitude would supply even three or four times the amount. But not only the rivers, even the streams and brooklets contain their quota of carbonate, and all are continually pouring into the sea the same substance, and this not for one year only, but for hundreds, nay, thousands of years.

The principal agent in this contribution is the mechanical and chemical dissolving power of rain water. There is no substance so hard, so durable and adamantine that will not eventually yield to the dissolving properties of water. Chemists, it is true, are wont to say that nitric acid will dissolve gold, that sulphuric acid will dissolve zinc, but not gold; and that water will dissolve neither of these metals. But this only holds good when we consider the process as being carried on only for a definite and small space of time, but when we carry on the process ad infinitum, then all such distinctions and limitations cease. The hardest rocks, the boldest mountains, will, in course of time, yield to the dripping action of rain water. At first the most prominent peaks and points will be rounded off, then they will cease to be altogether. After a time the shape itself of the rock will begin to change form completely, and it will grow smaller and smaller in size, till at length the last fragment is completely swept away. The rugged peaks of the



THE BRIDGE OF NIPHON BASHI, YEDO, JAPAN.

mountains in North Wales, the needle points of so many of the mountains in North Italy, and the grotesque and fantastic shapes worn by the rocks in Cornwall, especially those that go by the name of cheesering, are all owing to the action of rain water. Thus, in the course of centuries, not only hills and rugged mountains, but even entire continents, lose their shape, and are swept away through the agency of rain showers.

And marvelous indeed is the history of that process. The rain drops that descend upon a hard and solid rock, and leave it impregnated with tiny particles of its substance, can follow one of two courses. They can either descend into the earth, carrying their prey with them, or, owing to the hardness of the surface of the soil, they flow over its surface and rush down to the nearest stream, depositing therein its burden. Sometimes, when they take the first course, we have, as a consequence, the caverns of stalactite and stalagmite, such, for example, as the celebrated caves of Cheddar, in Somersetshire. Let us follow with the eye of imagi-

nation a drop of rain, which, laden with tiny particles of carbonate, sinks down beneath the surface of the earth. After arriving at a certain distance it reaches the ceiling of a cave, of which there are so many formed, both naturally and artificially, beneath the surface of the ground. It shows itself trembling and glistening on the ceiling of the cavern. In time, by the action of the warmth and of the atmosphere, the carbonate begins to coalesce, harden, and finally to attach itself by the force of attraction to the surface of the ceiling, after which the remainder of the drop, owing to the pressure of another from behind, falls perpendicularly to the ground. But it does not fall empty handed. It still contains a tiny portion of carbonate, and this, as the water gradually dries up, becomes deposited, a firm, solid crystal upon the floor of the cavern. Another drop oozes out, deposits its burden of carbonate in a similar way upon the floor and ceiling of the cavern, then another and another. Then, by degrees, two beautiful needle-shaped crystals are formed, one pendant from the roof, the other rising from the floor. Both continually increase in size, till at length they touch and unite. In the case of Cheddar these needles, called respectively stalactite and stalagmite, can be seen in the actual process of formation. Crowds sometimes flock to see them, attracted, not so much by the interest of their formation, but by the beautiful and very often fantastic shapes they assume.

But let us suppose, on the other hand, that the surface of the soil is of a hard and solid nature. In that case the drops of water, with their burden of carbonate, will trickle over the surface till they arrive at the nearest stream. From thence they will be carried to some large river and eventually exported into the boundless waters of the ocean. Another cause that is at work in the dissolving of the dry land and depositing its material in the sea is the action of the waves upon our coast line, and sometimes the gradual subsidence of the coast line itself. Such depredations are sometimes only the work of time, but occasionally it happens, owing to some unprecedented storm, or some extraordinary fluctuation in the tides, that a whole piece is carried off bodily and swept into the sea.

These two causes, quite apart from any other accidental ones, are sufficient to account for the presence of carbonate in sea water. It is moreover easy to see that even if only these two were at work, the quantity of solid carbonate held in solution in sea water must be enormous, nay, in the course of some years, the ocean would be more than saturated with it, and owing to its overwhelming presence would soon cease to fulfill its all-important functions.

There must, therefore, be some means of eliminating its superabundance from the ocean, and these, following the guide of experience and observation, may be classified into the following: First, the fish that live in the sea; second, the coral insects; third, the action of storm and tide. First of all, we must remember that the carbonate is not allowed, generally speaking, to remain at the outlet of the stream or river that deposited it. It is immediately carried far out into the ocean and diffused even to the uttermost parts. The waters of the sea are continually in motion. In addition to tidal action the great currents that, with gigantic and impetuous force, rush from continent to continent, the action of the sun upon the surface of the sea warming certain parts of it more than others, thereby causing the colder waters to rush up and take the place of those that have been carried off through evaporation, are sufficient to produce an incessant motion in the waters of the sea. Moreover, apart from these causes, there is another. Even in the retired depths of the ocean, where, as it is supposed, the rays of the sun can never enter, there exist living creatures with perfect moving organisms. Many of these, it is true, are exceedingly small and stationary, but, even so, they take and excrete their food, and this is quite sufficient to produce a downward and upward motion in the waters that surround them. It can be proved that such is the equilibrium of the great ocean, that not one single drop of it can be moved and displaced from its former position without producing a motion, small though it can be, in every single drop that constitutes the entire ocean. The drop that is moved vacates a certain spot, this is immediately filled up by the one that is nearest and so on, through the entire mass of water. Thus, if but a single drop be moved on the shores of Kent, the movement must be propagated through the entire mass of waters, even to the coast of Africa or Australia. Thus, while the currents move the upper and middle portions of the sea, the denizens of the depths are able to produce with their living organisms both downward and upward currents. Granted, that by the incessant movement in the waters of the ocean the particles of carbonate are diffused throughout its entire mass, it remains to consider the way in which its superfluous amount is carried off by the fish living in the sea.

The immensity of the fishing trade, the numbers that are able to gain a living by its means, are sufficient indications of the enormous quantities of fish, both moving and stationary, that live in the ocean and feed on its contents. The immense shoals of fish that sometimes almost form a solid mass miles in extent, and those huge monsters that are a terror even to man himself, are all most important factors in carrying off the surplus of carbonate that is daily being poured into the sea. For of what are their skeletons composed? What is it that constitutes the chief element of their bony structure? None other than that identical carbonate that is being washed in tons by our great rivers into the sea. The gelatinous maw of the fish contains but a small portion of it, but the bone consists for the greater part of carbonate. The living organism feeds on the tiny particles of carbonate floating loose in the water, it absorbs into its own system, and strengthens and enlarges its osseous structure. These are the flying scavengers of the sea, but the bulk of their operations is not so substantial as that of the stationary inhabitants of the deep. Those immense beds of oysters that extend for miles and propagate themselves in millions make their shells from the loose particles of carbonate. Those beautiful shells that are cast by the waves of the sea on our shores are all made out of the same material. Nay more, those huge cliffs of white chalk that characterize the south-eastern shores of our island extending from the east of Dover are composed, as the great naturalist Ehrenberg tells us, of minute microscopic shells which were formerly the tiny bones of minute living organisms. But what are those immense beds of black shining flint, of which there is a bed on the east of Dover two miles in extent? Who would imagine that that solid mass with which sometimes even great buildings are erected, notably at Ramsgate, who would imagine that that was once the appurtenance of living, moving, and palpitating organisms? Yet such is the case, for in many of them have been found the remains of sponges, and such like rudimentary, but living and beautiful organisms. But if we consider the larger shell fish, immense crabs and tortoises, still more palpable and evident becomes the great economy of nature, that makes use of these apparently useless beings in order to eliminate the superfluous quantity of carbonate that would otherwise choke the ocean, and indirectly be the means of destroying every living thing on the surface of the earth. But down in the depths of the ocean, there can be no living fish, not even crabs, or shell fish, who, feeding and building up their hard structure, can perform, for the lower parts, that which they have done for the upper. Such was the opinion prevalent some few years ago. It would seem impossible that at the bottom of the great ocean there should exist any life at all; still less, that there should exist an organism capable of performing the most delicate functions of the most complex life. The pressure of the upper upon the lower strata of water is barely conceivable till we judge of it by the effect it is capable of producing. The strongest cast iron submarine boat could not withstand the pressure. Jules Verne has, indeed, in his marvelous work, entitled "Twenty Thousand Leagues under the Sea," shown that by constructing a submarine boat of a certain form, its power of resistance might be immensely increased; but, even so, what must be the enormous weight of so many tons of water, which not only practical engineers, but even the imagination of the novelist is barely able to cope with? Added to this difficulty there is the fact that the rays of the sun, which, ordinarily speaking, are essential to the well being and propagation even of the inhabitants of the deep, can only penetrate a few feet, or at most a few yards beneath the surface of the sea. But deep down not the faintest glimmer of sunlight can possibly reach. It is no wonder, therefore, that up to a few years ago it was believed that the deep depths of the ocean were void of all life.

Recent researches, however, have succeeded in discovering the contrary. As the topmost peaks of almost inaccessible mountains are the abode of living creatures, though of course in fewer species than what are found in the plain beneath, so in the lowest parts of the earth, under the pressure of miles and tons of water, where no human being has ever visited, where no sunbeam has ever flitted, in the midst of solemn silence and perennial calm, dwell not only one or two, but thousands and millions of living organisms. In the deepest part of the Atlantic a dredge was let down miles below the surface, and, to the astonishment of all, minute living creatures were brought to the surface. They were, moreover, not only capable of fulfilling all the functions of life, but were possessed of eyes, eyes clear and sparkling, and which formed the most perfect image on the retina.

This last phenomenon caused a great amount of wonder and conjecture. If they are able to see, there must be light at the bottom of the sea. Even if they were born with the most perfect eyesight, yet if they were kept in a state of darkness for any considerable time, the power of vision would soon become entirely lost. But whence comes this light? One of the hypotheses that was brought forward sought to account for it by the emission of phosphorescent light. The fact itself which they adduce as the cause is no doubt true in itself, and is now matter of common knowledge. In certain parts of the sea acres and acres of water seem aflame with it. A vessel passing through the water leaves a huge track of molten fire behind it; an oar dipped into the water, on being raised lets fall drops of the purest light, which shine like brightest diamonds, and all this owing to the wonderful power which these insects have of producing, by the action of their instinct on their material organisms, the changes necessary for the production of the light. But many of these tiny beings drawn from the depths are not capable of producing such a light. The well known experiments of Professor Tyndall here come to our rescue. He discovered that immense pressure is capable of producing light. That there is immense pressure at the depths of the sea there can be no doubt, and here we have a sufficient explanation for the clear and perfect organs of vision with which these tiny creatures are endowed.

But these tiny beings are not only of interest as far as their outward appearance goes, they have a very important function to perform, none other than that of feeding upon and subtracting the superfluous particles of carbonate contained in the sea. There are millions and millions of them, occupying leagues of square miles under the great mass of our ocean waters, and each of them is a scavenger clearing off the superfluous carbonate that would otherwise soon clog the lower strata of water.

But this is not the only kindly office they perform. They establish a system of currents upward and downward. The water at the top is saturated with carbonate. As a natural consequence, being heavier than the water surrounding and beneath it, it sinks. When it reaches the depths these tiny creatures pounce upon it, and abstract therefrom the solid particles, which go to form their tiny shells. The water having deposited its burden, and thereby rendered specifically lighter than the waters above, arises to occupy their place.

We now come to the second means by which the superfluous carbonate is removed from the ocean—viz., the coral builders. Perhaps there is none of us that has not from time to time admired those beautiful necklaces of coral brought to us from the Polynesian islands. The hardness and durability of the structure, the clearness and brilliancy of the color, which is either red or white, may well make them such ornaments of which any woman may be proud. But these also are like the shells of the fish, simply the product of living organisms, and are manifestations of precisely the same function as that which is performed by the minute insects at the bottom of the ocean. Circumstances alone form any ground of distinction. The coral insects cannot live at any considerable depth below the surface of the sea, nor therefore can exist very far out from land; as a rule, they perform their labors only a short distance from land. They are prevented from going out further by the depth of the sea, and they cannot approach nearer to the shore, for then they would come in contact with the fresh water of the streams and rivers, which to them means downright destruction. The coast of Australia is lined for thousands of miles with the coral reefs, thus illustrating the limits that circumscribe the efforts of these tiny workers.

Their function is also to abstract the carbonate from the living deep, depositing it again in the form of coral. If, moreover, we examine the situation, the position in which these workers are placed, we shall find a most wise disposition of things. They are placed just in the way of the warm currents which contain the greatest quantity of carbonate. If there were no current to supply them with a fresh amount of carbonated water, they would very soon perish for want of their necessary aliment, as it is the current supplies them with a never-failing provision of food, and they, in their turn, take from it the quantity of carbonate with which it was loaded to excess.

Such, then, are the instruments by which the superfluous quantity of solid carbonate is removed from the waters of the sea. But what we see now has been going on for ages. The greater part of the dry land on which we stand is the product of the silent denizens of the sea. There are huge chains of mountains built up entirely, or almost entirely, of carbonate, that centuries ago has been abstracted from the sea. It is true that in them are also found many other substances, but the carbonate always holds the most important place. Immense tracts of land, too, covered with green pasturage, or majestic forests, are composed of the same material. The invaluable discoveries made of late years by geological science show the immense importance that marine products hold in the strata of the earth. Millions of years ago, when this dry land was buried under the waters of the sea, what is now being done by the coral insects and moving inhabitants of the sea, was then being done by those beautiful fossil fish of which so many specimens still exist, while now, as then, we behold in the silent hidden labors of present sea life the germs of continents, which will rise slowly and majestically into existence millions of years to come. How beautifully does not all this accord with the wisdom of eternal Providence, who in His ineffable law of least means makes use of the lowliest of His creatures for the accomplishment of His greatest designs!

Having now considered the carbonate, and the elimination of its superfluity from the waters of the sea, we must now pass on to consider a subject, of as great but more intricate interest, namely, the presence in due quantity of sodium chloride or sea salt. It is well known that common salt is found in every part of the ocean, but not every part is equally saturated with it. In those regions where the sun is intensely hot, and where as a consequence a greater amount of vapor is carried up, there more salt will be found, for the heat cannot raise the particles of salt except in such infinitesimal small quantities as to be altogether imperceptible. The water, therefore, that is left behind is rendered salter. In those seas, on the other hand, in which little evaporation takes place, the quantity of salt is comparatively less. Such is the case in the Baltic Sea, where the waters are almost fresh in their quality.

The sodium chloride, or common salt, that is found in the sea can be attributed to the same source as the carbonate. It is poured into the ocean, that is to say, by the rivers and streams of our continents and islands. Our rivers, though supposed to contain nought but fresh water, yet, in reality, contain small quantities of salt, which being carried hourly, and daily, and yearly into the sea, soon suffice to saturate it thoroughly with the briny element.

The amount of salt contained in the sea is so great, that if it could, by some powerful process, be abstracted from the sea and spread over the northern part of our continent, it would cover the ground to the depth of one mile; and this quantity would, if there were no removing agent, be continually increasing, till our great oceans would, in course of time, become as salt and as deadly as those of the Dead Sea. The continual evaporation that is carried on is one of the principal agents in its increase. In vast tracts of the ocean, where the heat is greatest, 15 feet of surface water in the course of a year is lifted up into the air, leaving behind its residue of salt, and this process is carried on for thousands of square miles. Then only a small quantity of the vapor thus carried up returns direct to the sea. It is borne away by aerial currents to terrestrial regions, there it is precipitated in the shape of rain, which percolates through the soil, and enriched again with a burden of salt, returns to the briny deep.

There must, therefore, as in the case of the carbonate, exist some agent or agents by which the superfluous amount of salt is removed.

What the effects of this agent are, we have in the numerous salt mines that have been discovered in the bowels of the earth, and which rival in size and magnificence even those of the coaling districts. One of the most important of these, and which for its peculiar structure leaves the strongest impression upon the mind, is that at Salzburg. The salt is there obtained by a process of saturation and distillation. Water is allowed to flow into a basin of salt until it becomes absolutely saturated with it, upon which the water is boiled off in a series of vats, leaving behind their residue of hard, solid salt, while long passages, excavated from the same material, lead from one part of the vast subterranean palace to another.

In various other parts of the world are found similar storages of salt, and all give clear and unmistakable tokens of being by some mysterious process extracted from sea water. The fossils that are found in the strata immediately surrounding that of the salt are those that pertain to marine shores, and betoken it as clearly as in our day the sea shells betray and characterize the presence of the seashore. Moreover, in the mass of the salt itself, buried beneath its surface, are found fossils of various organisms.

At first it was extremely difficult to assign any certain and definite cause for these enormous deposits,

and various conjectural theories were resorted to. One of these was the action of salt springs. Springs that rise from the earth usually deposit on the surface of the soil secretions of any particular mineral with which they are saturated. Thus springs of iron water invariably characterize their presence by a red sediment of iron varying in thickness and solidity, according to the circumstances of the locality. If it be a spot well protected from the heavy rains, and yet exposed to a certain amount of heat, the quantity of mineral found on the surface will be greater than that deposited in less favored localities. In the same manner springs of salt deposit their burden upon the surface of the soil immediately surrounding them. But these deposits, even though we imagine them as being found under the most favored conditions, yet never amount to more than two feet in depth at most, and certainly hold no proportion whatever with those huge masses which strike with wonder the eye and imagination of the beholder. Another hypothesis was that of the action of storms. It was supposed that on a flat coasting line the sea would advance more than usual into the interior of the land, and afterward retiring would leave behind small ponds or lagoons of sea water, which being dried up by the sea, would leave large deposits of the salty element. But this hypothesis has also been found totally inadequate to explain the effect in question, for such, unless made artificially for the purpose (and this is impossible, for we are treating now of prehistoric times), would only be of a very superficial depth.

There must, therefore, be some other agent at work. And a more enlightened knowledge of the transformations that nature carries on around us suffices to show not only that there is such an agent, but also what that agent is.

It is a well known fact that the surface of the earth is continually changing. Portions are rising gradually to a higher level, while others are undergoing a corresponding depression. Whether owing to the action of internal forces, or to the revolution of the earth itself, with such velocity through space, or as is most likely, owing to both these causes acting together, there is not one single part of the globe that is not undulating like the unstable element of the sea. Even the experience of the last twenty years has shown how lands, that were once under the surface of the sea, by a gradual upheaving from below, are now reclaimed, and teem with the labor and industry of man, while other parts of the coast, by a corresponding process of sinking, are severed from the mainland. A striking example, though, of course, of very ancient date, we have in the Straits of Dover. Research shows that the narrow "Silver Streak" was once terra firma, joining the now separated countries.

This gradual depression in certain parts of the globe is the chief factor in the removing the superfluous salt from the sea. By it certain parts of the sea are cut off from the main portion. Thus, in course of time, an immense salt water lake is formed. By degrees, owing to the action of the warmth of the sun and the evaporating influence of the dry winds, the water is gradually removed, leaving behind an immense deposit of sea salt. Thus the superfluity is removed by a two-fold process; first by the gradual subsidence and sinking of certain parts of the sea, and secondly, by the evaporation carried on by the action of sun and wind.

Such are the principal agencies in the storage of the carbonates and salts under the surface of the sea and the removal of their superfluity. In both cases it will be easily seen that there is a circle. The land gives to the sea, and the sea in its turn, by the work of its living inhabitants, and the subsidence of certain portions of its bed, gives back to the land, and furnishes the material of future continents and islands. As to where the circle begins, it is impossible to say. As we said in the beginning, the circle is found in nature, and all we can do is to follow its harmonious and progressive movements with ever-increasing wonder and admiration.

[Continued from SUPPLEMENT, No. 975, page 15580.]

METHODS OF MINE TIMBERING.*

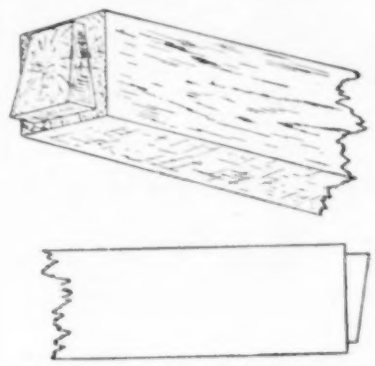
By W. H. STORMS, Assistant in the Field.

IRON DOGS AND BOLTS.

IN places where the previously described methods of building sets of shaft timbers on reachers is not possible, owing to the soft nature of the rock in which the shaft is sunk, or where it is desirable to run cages to the bottom of the mine, it was formerly the custom to suspend the shaft timbers by ropes in a position as near to that desired as possible, and to then maintain them in that position by driving iron dogs into the timbers, the weight being supported by the set next above, which had previously been secured by wedges. In some cases these dogs were never removed. Many of them may be seen in the older California mines. The dogs were made of round or square iron bars 1 by 1 in. or 1 by 1½ in., and having the ends turned at right angles. The points were 3 or 4 in. in length and sharp. The length of the dog was determined by the distance from center to center of the sets.

When the rock was sufficiently firm to admit of the timbers being firmly wedged, the dogs were knocked out. Iron dogs or bolts are useless as a means of support when the surrounding rock masses have once firmly settled on the timbers.

A safer and more convenient device has been introduced in later years, in the form of iron bars having a thread at one end and a ring or hook at the other. These go in pairs, their combined length exceeding by six inches the distance from the top of one set to the bottom of the next set beneath. The manner of using these hangers is as follows: A set having been securely wedged in its proper position, the threaded end of the bolt provided with a hook is passed upward through a hole in the plate (bored in all timbers for the purpose), a washer passed over the end of the bolt, and a threaded nut screwed down on to it. A second "lock-nut" may be used, but is not necessary. A second similar bolt with hook is passed through a hole near the opposite end of the same timber, and also secured with washer and nut. The timber to be placed directly below is suspended by ropes in a position approximating that desired, and a bolt having a ring at one end is passed downward through this timber, immediately below that in the timber above, and a similar bolt is passed through the opposite end. Washers and nuts are placed on the ends of these bolts, and the rings are caught in the hooks of the bolts above. The nuts may now be turned and the timber drawn to exactly the position required, when the ropes may be removed. All four of the timbers of this set having been placed in position, and being suspended on the hangers, the posts are slipped in, the nuts tightened still further, and the whole firmly wedged, when the next set below may be put in in like manner. The hangers are left a few days or weeks, and, in some instances, permanently; but, as previously stated, they are useless as a



MANNER OF FRAMING DIVIDER

means of support when the weight of the surrounding rock has settled on the timbers.

Where, owing to the soft nature of the ground, it is thought desirable to have the hangers remain in place indefinitely, a bar having a thread at one end and simply turned at a right angle at the other, or having a solid hammered head with a washer, may be used, being passed upward through the bottom timber and then through that above, where the adjustment is made by means of a washer and nut; but as these bars are longer than the distance between sets, their removal is impossible, a set below once having been put in place. There is no question as to the superiority of the bolts having rings and hooks for either temporary or permanent use.

RETIMBERING SHAFTS.

It very frequently occurs that shaft timbers have to be removed and new ones inserted, and also often necessary to re-enforce timbers already in place. This work frequently necessitates the suspension of hoisting through the shaft. The superintendent of the Wildman mine, at Sutter Creek, Amador County, Cal., having occasion to retimber the shaft between the five hundred and six hundred levels of the mine, constructed a chute one foot square of two-inch plank in one corner of a compartment of the shaft reaching between these levels. It was built in short sections, each the length of a set of timbers. The work of retimbering was commenced above and carried downward, all of the refuse rock, timber, etc., being dumped into the chute. This material was taken up on the six hundred level, dumped into a skip from time to time, and sent to the surface; by this means the work was quickly and safely carried on, sections of the chute being removed to keep pace with the work. By means of this device there was very little delay in operating the skips, and hoisting of ore was continued almost without interruption during the retimbering of that portion of the shaft.

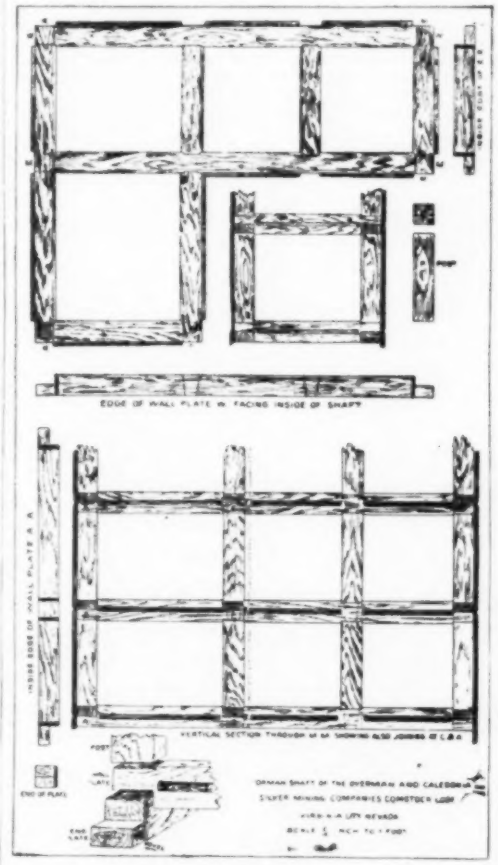


FIG. 15.

SHAFTS HAVING TWO OR MORE COMPARTMENTS.

Large shafts are separated into two or more compartments by placing timbers called "dividers" at intermediate points between the end plates. They reach from the wall plate on one side to that on the opposite side of the shaft. These dividers are framed with a short beveled tenon, broader at the top than at the bottom. (See cuts of Forman, Requa, and Alma shafts.) These tenons fit exactly into mortises or notches in the wall plates. At each of the four corners of the shaft, and between the wall plates opposite each divider, is placed a post, which is set in a shallow notch or seat in the plates. In size the posts may equal that of the plates, or, if desired, they may be of smaller dimensions. The dividers are made the same depth as the wall plates, but are usually narrower across the upper face.

The dividers separating shafts into two or more compartments may be made most secure by permitting the upper portion of the beveled tenon to extend into the wall plate two or three inches, the bottom portion being let in but one inch. The post setting directly on the divider holds it much more firmly, and the danger of having the dividers knocked out by shots fired directly below is greatly decreased, if not obviated entirely. It not infrequently occurs when dividers are framed so as to set but one inch into the wall plates a heavy blast will tear them out altogether, incurring expense of timber and time, which may be avoided in the manner stated above.

Drawings of two Comstock shafts illustrate the manner of framing and placing timbers in them. One of these is called an "L" shaft, and was sunk by the Overman and Caledonia companies jointly. It is known as the Forman shaft. The other is the Requa shaft, sunk by the Chollar, Norcross, and Savage companies. It is a large rectangular shaft, having four compartments, and is a splendid example of its kind. An illustration of the new Alma shaft at Jackson, Amador County, Cal., shows a different style of framing. In fact, the manner of framing and joining the timbers of these three shafts is totally different.

In size, shaft timbers range from 8 by 8 to 20 by 24, and even larger dimensions are sometimes employed in very heavy ground, particularly in inclined shafts. The wall plates are usually broader on one side than on the other, and are placed in position with broad side up. End plates are usually the square of the smaller dimension of the wall plate.

Pumping and manway compartments do not require lining, but hoisting compartments, particularly where cages are run, should be lined throughout to prevent accident to men who sometimes overcrowd a cage. There appears to be less danger of this where buckets or skips are used. Every shaft in a mine should be provided with ladderways as a means of exit in case of accident to shaft or hoisting machinery.

Sinking large shafts in swelling ground, in loose, watery, running ground, or in quicksand, greatly multiplies the difficulties and dangers of the miner. There are instances where shafts have been abandoned owing to insurmountable obstacles which a combination of engineering skill, capital, and labor were unable to overcome, but such instances are of rare occurrence. Few shafts present greater difficulties than were encountered at Leadville, Col.; in the Lake Superior region; in some coal mines; on the Comstock, and in Calaveras and Amador Counties, Cal. (the latter are mostly inclines), and some of the shafts in the regions mentioned are to-day splendid and substantial monuments to American engineering and to the enterprise of the companies owning them.

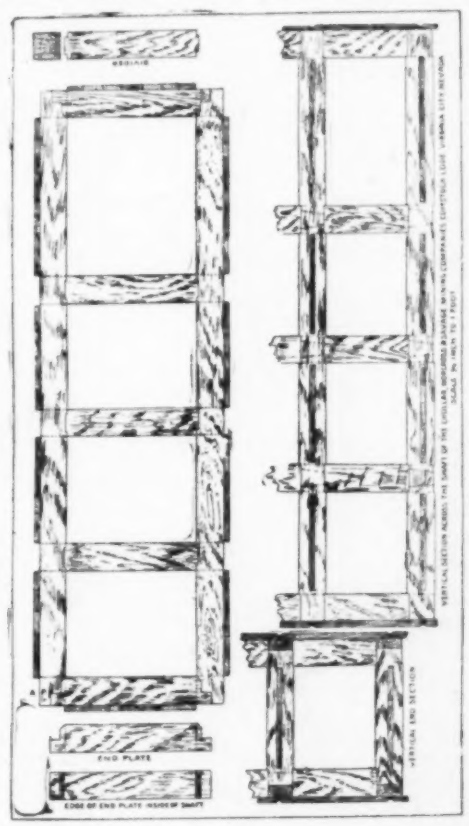


FIG. 15A.

The shaft of El Capitan Mine, Nevada County, now the property of the Providence Mining Company, was sunk through decomposed slate and altered dike rock under the most trying and dangerous conditions,

* From Bulletin No. 2, California State Mining Bureau. Dr. J. J. Crawford, State Mineralogist.

After several failures, the shaft was carried down to solid ground under the direction of Francis Burns, who worked slowly and carefully, giving the soft running ground time to drain. The water being pumped from the sump, after standing for a time, appeared to drain the ground, and it was found that by this means progress was much more rapid than when the work was hurried. "Breast boards" were carried down until the dangerous places had been safely passed.

It is sometimes necessary in sinking large shafts to carry them down in sections by driving lagging or planks down in advance of the excavation. This is known as "fore poling." The section is started at one end of the main opening and advanced several feet, the lagging being well braced. Considerable water will drain into this depression, making the removal of the ground from the remainder of the shaft much easier. By carrying one side of the shaft somewhat in advance of the remainder, in this manner loose, wet ground can be worked more quickly and at less expense than when it is attempted to carry down the entire shaft at once.

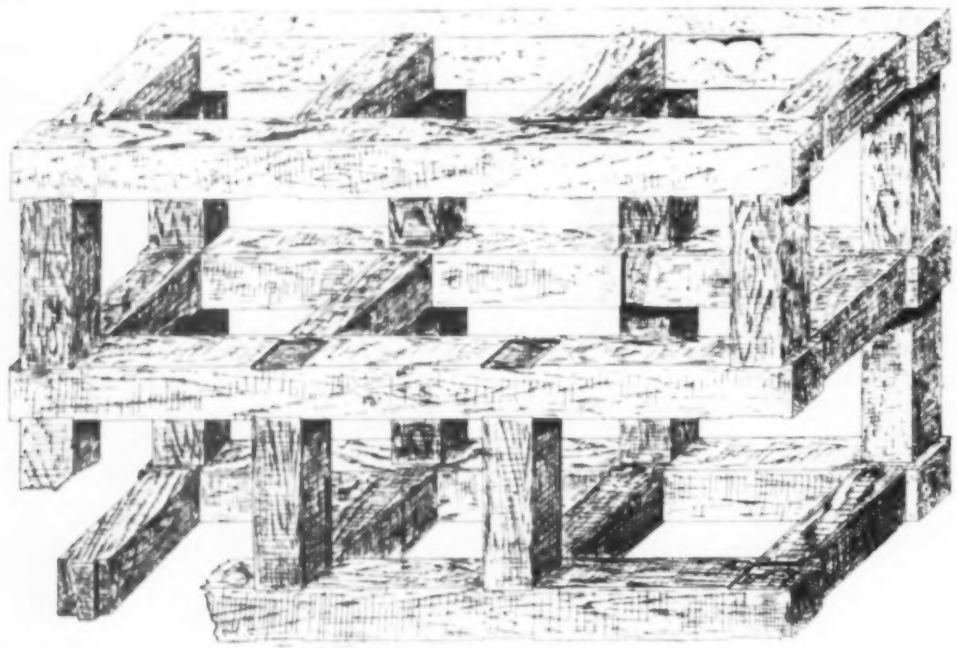


FIG. 15B.—THE METHOD OF TIMBERING THE ALMA SHAFT AT JACKSON, AMADOR CO., CAL.

SPLICED WALL PLATES.

In cases where sinking cannot be carried on in shafts much in advance of timbering the wall plates may be spliced. The better plan is to extend the plate from one side entirely across the two hoisting compartments, that portion in the pumping compartment being in a single piece, and joining the longer piece directly opposite the divider next to the pumping compartment. These joining ends of the two sections of wall plate should be framed so as to permit the divider to lap over their entire width, the upper half of the plate sections being removed so as to admit the upper half of the divider, as shown in the illustration.

The post standing immediately upon the divider, and covering the entire splice and overlap, prevents the divider from being blown out by heavy shots below. This plan also greatly facilitates the placing of shaft timbers, as there is not that great loss of time in getting the wall plates in position which results when long timbers are handled. There is always difficulty and loss of time where the shaft cannot be carried down in advance of the timbers far enough to give room to turn the long wall plates. This system also permits of the renewal of wall plates and other shaft timbers by the ease with which they may all be removed.

BREAST BOARDS.

When the ground has a tendency to thrust itself up in the bottom of the shaft, the plan of planking and bracing the ground is sometimes resorted to. (The same principle is applied in drifting, when the method is referred to as "carrying breast boards.") In this method lagging is driven down in advance of the sinking, being supported in position above by a frame of timbers, either permanent or temporary. Planks are laid on the bottom of the shaft, being secured by upright posts, which abut against strong stulls or cross-pieces firmly wedged above. When the pressure from below begins to exert itself, a board near the center is removed and the soft, pulpy mass allowed to force itself upward. The material is removed until the ground is eased somewhat, when a second board is removed, the first being replaced somewhat lower than before, and again secured; the material coming up through this new space is removed as in the first instance, and in this manner work proceeds entirely across the excavation. The process is slow and requires considerable timber, but it is a plan which may prove successful when all others fail.

The method of driving lagging in shafts is similar to that explained under the head of drifts. (See Fig. 12.)

In some instances iron caissons have been sunk outside or inside the timbers to enable miners to pass through very loose, watery ground and quicksand. Where this is not absolutely necessary, wet places have been passed through by making a clay lining between two layers of close planking. It may be from 2 inches to 1 foot in thickness, according to the requirements. It has been successfully employed in passing through quicksand and watery, loose ground.

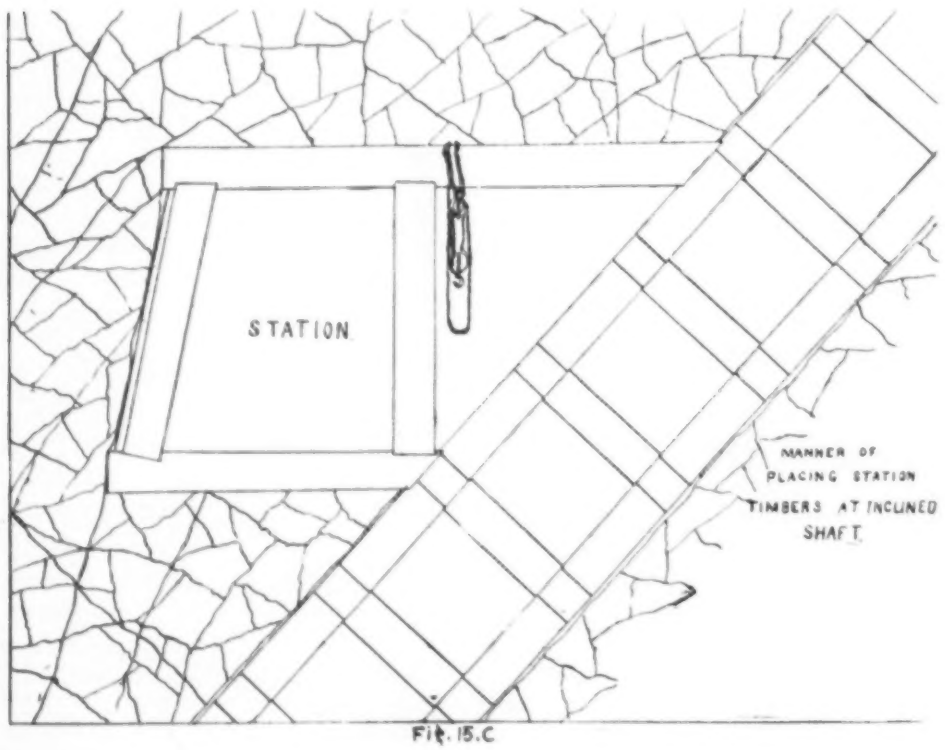


Fig. 15.C

In very bad wet ground the idea is to form a caisson-like structure with lagging, the interior being sustained, as explained above, by massive timbers so placed as to resist the pressure of the surrounding rock mass. The exigencies of each particular case must determine the course to be pursued.

The expedient of freezing soft, wet, running ground, quicksand, etc., is now much resorted to with great success. It is a patented process, but finds general use where applicable.

Circulars shafts are seldom sunk in America now, though very common in the early days in California. There are circular shafts all through the old river-bed region, which pass down through the tufa capping without a single stick of timber from top to bottom. Many of them are over 250 feet in depth, and notwithstanding they were made more than forty years ago, are still in good condition and likely to remain so for a century. The rectangular shaft is the most common form in this country. "L" shafts do not find much favor and have nothing to recommend them. The size and number of compartments of a shaft must be determined by the amount of hoisting expected to be done through it.

STATIONS.

The accompanying sketch shows the manner of placing timbers at station in an inclined shaft. The method in perpendicular shafts is essentially the same. The chain blocks are for the purpose of landing timbers sent down in the skip.

JOINING OF GUIDES IN SHAFTS.

Guides in shafts where cages are used or where skips run on guides should be so joined that there is no likelihood of their warping and projecting beyond their plane, and jam the cage, or skip, which is a most

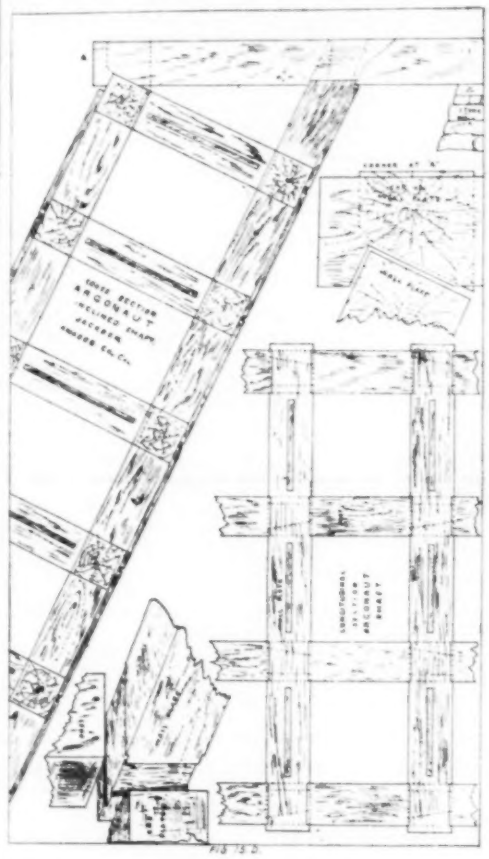


FIG 15.D

dangerous thing and a great strain on the cable. The overlapping of the ends has been for years a common practice; the two ends being secured at the overlap by a single lag bolt. An improvement has been made on this plan, with a view to greater safety, by joining the adjacent ends of sections with a simple tongue and groove, like ordinary flooring or wainscoting. The ends each have a lag bolt, which makes them doubly secure. The drawings show both styles for framing guides. Spikes or nails should never be used, as it requires much more time to remove a section when repairs are necessary. Guides are most easily repaired by laying a secure platform in the compartment at the point requiring repairs, the men working upward from set to set. Should the whole shaft, or any large portion of it, require new guides at any time, the platform should be put in as described. The hood is removed from the cage and a bottom of loose boards laid on the floor. The workmen at the platform unscrew the lag bolts and take out the old, worn guides. The cage being lowered to the proper point, the old guides are passed up through a hole made in the bottom of the cage, and the new guides passed down in the same manner and put in place. In this way the guides may be removed for a thousand feet in a single day by a gang of good workmen. Other repairs in the shaft may be made in a somewhat similar manner.

INCLINES.

Inclined shafts are somewhat different from those that are vertical, and are probably quite as numerous. In California the number of inclined shafts far exceeds those that are vertical, being, as a rule, sunk on the vein, which, in a majority of cases, dips at some angle from the horizontal. In a general way what has been said of vertical shafts applies to those that are inclined. There is considerable difference, however, in the manner of framing timbers for an incline, and while timbers framed for an incline will do, perhaps, equally well in a vertical shaft, those framed as already shown in the illustration are not preferred in an incline. An

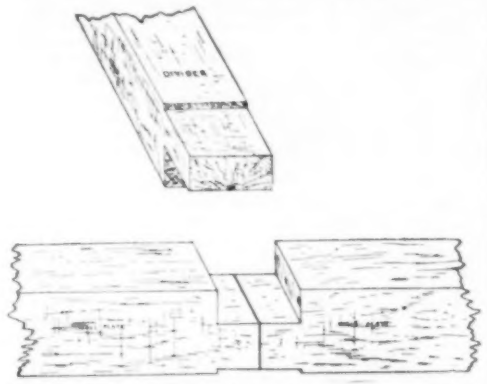
illustration of the method of framing timbers for the new Argonaut shaft at Jackson, Amador County, California, which is expected to reach a depth of 2,000 feet on the incline (63°), is given. It resembles somewhat the new Alma shaft, also at Jackson, though the first 400 or 500 feet of the Alma will be vertical.

STOPES AND CHAMBERS.

The cuttings in mines which require the most care and greatest skill in placing timbers to support overhanging ground are "stopes" and large "chambers." The method adopted must always depend upon the size of the excavation, character of the ore and of the walls, the pitch of the vein or ore shoot and also on the expense of the timber.

TAKING ANGLES AND DISTANCE BETWEEN WALLS.

A very convenient instrument for measuring the distance between the hanging and foot walls of the vein, and to determine their respective angles of inclination, for the purpose of cutting stulls with proper length and bevels, is shown in the accompanying illustration. It consists of two flat planed boards having slots, as

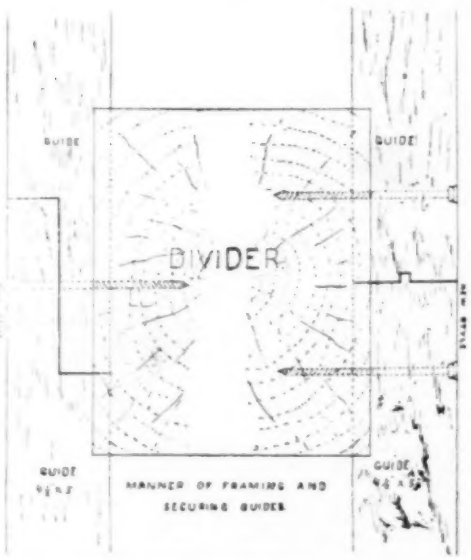


FRAMING FOR SPLICED WALL PLATE AND OVERLAPPING DIVIDER FOR SHAFTS.

shown in the drawing, and fitted with thumb screws, S S S. At either end is a movable arm, A A. These are placed against the walls and the screws tightened, the distance between walls being ascertained by lengthening or shortening the instrument by means of the sliding arrangement. Having carefully taken the required measurements, there can be no mistake as to the kind of stull required.

TIMBERING A SOFT HANGING WALL.

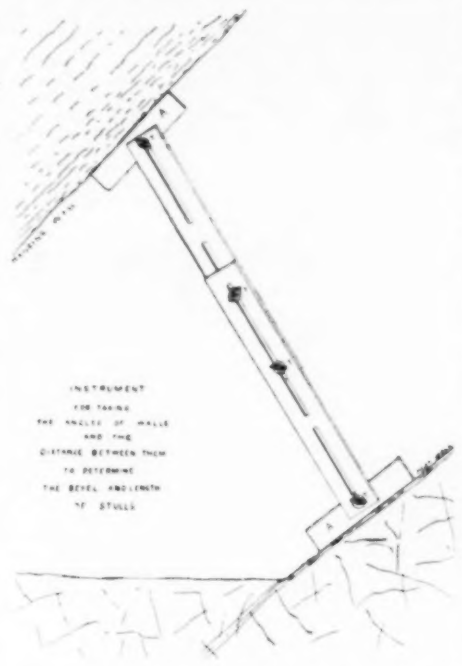
In some portions of the New Almaden Quicksilver Mine, where the width of ore stoped is about 10 feet, an unusual method of timbering has been adopted. The foot wall is usually hard and solid, while the "alta," as the hanging wall is called, is almost always soft and shelly, and is considered dangerous ground. Heavy stulls are placed at regular distances (about 8 feet), and are set in line one above another. Immediately above the stull a second shorter timber is laid, which rests upon the foot wall and reaches within about a foot of the hanging wall. A plate or cap is inserted over the upper end of this auxiliary stull, which reaches horizontally across to the next stulls, which are similarly placed. Heavy lagging is driven upward along the hanging wall, the lower ends of which rest upon the cap and the upper ends upon the lower ends of the lagging of the next set above. The two stulls are bolted together near the top and bottom



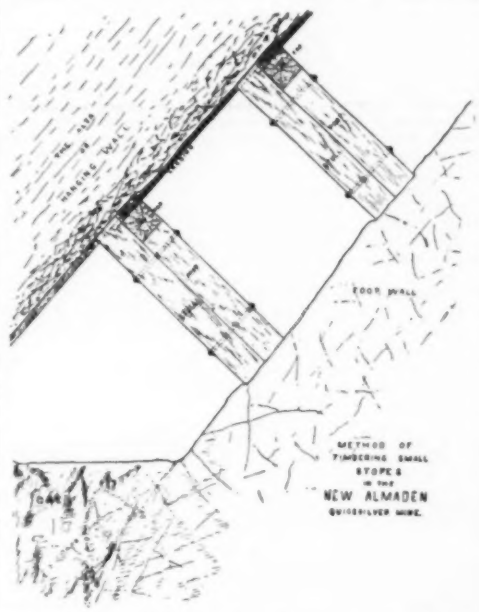
for additional strength and security. Redwood has been used quite extensively in timbering this mine, and it is claimed it has given satisfaction. The accompanying sketch will show this method of timbering. The large stopes of the New Almaden are timbered in square sets.

FLAT OR BLANKET VEINS.

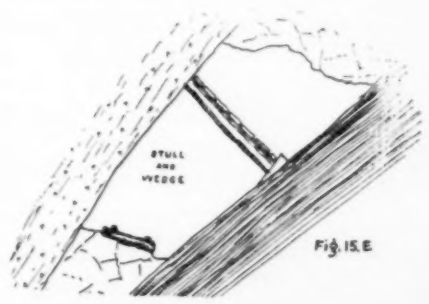
In veins which lie quite flat, the thickness of the vein and the system of mining must determine the character of timbering to a great extent, as well as the character of the walls. Where the vein is thin (a foot or two) very little timber is required, the waste rock filling the entire space behind the miner. Where the mineral deposit is thicker and timber is necessary various methods are pursued. Some ground stands well by simply leaving pillars of mineral. In other cases a series of upright posts and breasting caps will sustain the roof, the posts being placed in rows directly back of the workmen and as close to the face as the necessity demands. The foot of the post rests either directly on the rock floor or upon a block of wood or piece of heavy plank. The posts are forced into position by driving them up with heavy hammers. Care must be taken that these posts are so placed as to receive the



weight of the roof directly and not at an angle. These timbers are set in lines standing in two, three, or four rows back from the face, the waste being piled behind as the work advances. In this manner, by exercising care, many sticks can be recovered before the weight settles so heavily on the refuse rock as to render it impossible to remove the timbers. Some flat veins



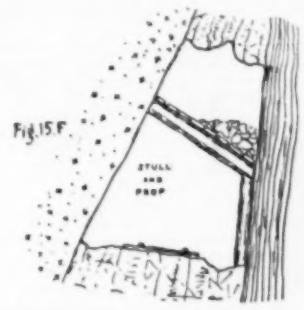
make little or no waste. It is then necessary to follow the "pillar and stall" system of extraction, considerable blocks being left to sustain the roof. Posts and caps are used in this system also. Frequently the caps reach in a continuous line from post to post, joining the next set, the ends of two caps resting on a single post, the combined sets being a hundred feet or more



in width. Large timbers thus placed will support great weight, but if small rocks fall from the roof lagging must also be employed. This system is much in use in California gravel drift mines.

When a vein lying nearly, or quite horizontal, and making no waste, is to be mined, a drift should be run along the lowest portion of the deposit, this point having been reached by incline or shaft. The work advances toward the surface, good sized pillars being left to sustain the roof. If timber is necessary, it is put in place in the manner required. The work having advanced sufficiently far toward the surface, the pillars may now be cut out at the back end, while the work progresses as before. As the pillars are removed more timber must be put in, or waste from the surface must be piled in cribs of timber built in the workings already made. Usually some timber can be recovered in this way and the caving of the roof after the complete removal of the ore, or mineral, does no harm. The main gangways should be substantially timbered, if necessary, as it is desirable to keep them open to the lowest working level at all times.

The "long wall" system of extracting ore is usually carried from the surface inward, a main gangway having been first driven ahead to a connection with a ventilating shaft, when possible. All the ore is removed at once, the waste being thrown back of the miners, who carry the breast forward with the center considerably in advance of the sides, the excavation being in



form somewhat like the letter "A," with the apex forward. The waste is thrown into the center to support the roof, while the side passages permit of a free circulation of air all along the face.

STEEPLY INCLINED VEINS.

In vertical or steeply inclined veins, the principles governing the methods of timbering are essentially the same as those above explained, though the application is different. In such workings the post of the flat vein becomes a "stull."

(To be continued.)

HARBOR DEFENSE.

WHAT with pneumatic dynamite guns, 10 and 12 inch steel rifles, 12 inch steel mortars, automatic gun lifts that play with great 52 ton cannon as if they were toys, and all the other recent improvements in coast defense, the day is near when New York City will be protected from danger of invasion by sea by an impregnable system of fortifications. When that day comes the artilleryman's fun will be over, for promiscuous target practice is hardly possible with big guns whose life is less than 50 rounds, while each shot costs $1,000. And should an enemy's fleet attack New York, he will have still less fun, for then he will be stuck away under a bomb proof where he won't know whether he scored a hit or a miss, because he won't see what he's shooting at.

Although not new, this will probably seem to the public the most interesting phase of the development of modern ordnance. There is no exaggeration in it, either. When the proposed system of fortifications is finished, should there ever be an attack from the sea, only a few dozen officers and men would be where they could see the attacking fleet at all. Almost all officers and men would be below bomb proofs, in concrete, steel-lined gun lifts or deep in vaulted mortar pits.

Down there, where nothing can be seen except the huge breech blocks of the great guns and the complicated machinery for moving them, the cannon will be loaded, aimed, raised over the steel-plated parapet and fired, and not a man will know what he fired at or whether the shot did any execution. The method by which this is accomplished is much more simple than would be expected from this statement. It is this:

The United States Engineer Corps has carefully plotted out on a map all the channels and deep water basins and holes around New York, and then the map has been covered with little squares each of which is numbered. Each square represents the "danger area" to a ship; that is a shot fired anywhere in that square would hit a vessel stationed there. Now suppose all the different forts have their mortar batteries, gun lifts, etc., which have been designed for them, and an invading fleet is sighted approaching Sandy Hook. At once every gun's company is told off to its station.

The officer in command of each gun has a table giving the numbers of the squares, and opposite each number telling him just what elevation and what lateral direction he must give his cannon in order to get the range. Each gun is connected by telegraph with an observation tower, in which are the officers commanding operations, together with signalmen and other assistants. They are all provided with range finders and glasses, and the map with the numbered squares is spread out before them.

As soon as the positions of the ships can be fixed, one of the officers begins to plot the course of the vessels on the chart. Finally, say one of the ships passes into square No. 27, and it is decided to fire at her when she gets into square No. 28.

"Tick, tick," says the telegraph to all the grim, hidden men behind the grim, hidden guns.

"Train guns on square No. 28." Around swing the guns, and the officers elevate or depress them by aid of level and azimuth. All is ready.

The observers in the towers have seen the doomed ship steam into square 28. "Ready!" says the telegraph. Up goes the great 12 inch gun on its disappearing carriage. Up flies the 10 inch rifle on its big gun lift. The dynamite guns and the mortars don't move. They are already trained on the square because they fire at a great angle. The ship passes into the square. "Fire!" ticks the telegraph.

With a crash that shakes the earth flames burst from a dozen different points, and the next instant a quarter of a hundred projectiles fall on the ship. The guns drop back behind their parapets and the deafen-

ed, powder blackened men clean them quickly and load again. They have nothing else to do. They cannot tell what effect their fire has had. They have seen nothing. They can hear nothing, unless shells from the ships fall on their gun pits and tear up the earth above them, trying to get at them.

This is no mere theory. It has been proved in practice that with the accuracy now absolutely attained by the modern breech-loading, all-steel, rifled cannon and the all-steel, rifled mortars, shot after shot can be dropped into a space less than that occupied by a modern ocean steamship.

The mortars will be placed in batteries of sixteen, consisting of groups of four, and the aggregate weight of the shells, if the sixteen should be fired at once, would be 10,000 pounds, besides being filled with explosive charges.

At a test at a range of five and a half miles, ten consecutive shots all fell within a space 195½ yards long and 8⅛ yards wide, about the same space as that occupied by an ocean steamship. Thus if an entire mortar battery, a 12 inch and a 10 inch gun, were all fired together (naturally not a likely circumstance), 11,800 pounds of steel would fall in one square. No battle ship afloat would be able to withstand this terrific assault.—N. Y. World.

THE MILITARY VALUE OF THE DONKEY.

By Lieut. L. D. GREENE, 5th U. S. Infantry.

THE humble donkey, or burro, seems to bear and expiate a curse that is never satiated. The butt of ribald jest, the standard of uncomplimentary comparison, the victim of contumely and harsh abuse before and since the day that Balaam was miraculously rebuked for his cruelty through the mouth of his long-eared and long-suffering beast, meek and lowly, his virtues seem ever destined to be lost in a neglected obscurity.

May it not be, however, that the despised burro is worthy of better treatment and regard? Speaking for myself, I can say that observation in the mountains of Colorado of the capabilities of the humble subject of this argument leads me to regard him as very much underrated. Wherever the daring prospector penetrates among the seemingly impassable rocks and cañons; where mines are opened far from beaten roads, and only accessible by paths and trails that try a man's full abilities to carry himself; up and down are seen tirelessly plodding the tuneful burros, packing sacks of ore down to the nearest wagon or railroad, and returning laden with all the necessities of operating a mine—provisions, tools, powder, candles, lumber and sheets of corrugated iron—that roof him in from away in front of his nose to far behind his rump; heavy and crooked pieces of machinery; all are somehow fastened to him, and somehow he steers his way up rocky and slippery trails with a certainty of foot like a goat, and more sense than some men.

Patient for hours, in storm, perhaps, he waits for his load, which, received, he virtuously and steadily transports to its destination, apparently dismayed or surprised by nothing. Blasts may be set off and rattle rock about his ears; trees fall and barely miss him, or any convulsion of nature take place, with no sign from him except the mild curiosity evinced when his long ears wave gently forward in disinterested wonder.

Knowing no other existence than one of hardship and abuse, he gleans a living from the brush and grass of the mountain, with an occasional empty tin can as a relish. He is absurdly cheap; ordinary dogs have as great a market value; six to twelve dollars will be sufficient consideration frequently for a change of owners, and his ornate saw-buck pack-saddle is worth from three to five, if good.

The price of a first-class pack mule with aparajo will pay for about sixteen of these little beasts, and these will carry seven or eight times the weight of freight that the mule will, and no one of them be as wild or stampede as easily as the latter; and to one who has seen his rations, clothes and cooking outfit impartially strewed over a square mile of country—more or less—by a frisky, bucking pack mule, the latter characteristic has a value.

Then, the mule may die or run off, and the loss is considerable, not only in money value, but in loss of service; while if the burro quits this life, the loss is proportionately small.

To sum up, then, the burro is docile, able, intelligent and cheap, and this combination has suggested to my mind his availability in a field not yet satisfactorily filled in the military service. The question of the supply of ammunition to the firing line has of late commanded the attention of many writers but their suggestions do not seem to have entirely solved the problem, and I therefore add one more suggestion to the list.

With the new quick-firing arms and the consequent consumption of large quantities of ammunition, this question of supply of the firing line has gained a great importance. The impossibility of an infantry soldier carrying enough cartridges with him to last out a whole day's fight is too apparent for discussion. Plans for renewing and keeping up the supply have comprehended the use of men, horses, mules and even dogs; and packs, wagons and carts of all kinds. In the character of country in which our army will probably always serve—rough and more or less wooded—I deem anything with wheels as wholly impracticable for general reliance. Men can be put to better use than in carrying freight, especially when the number needed for supplying a company of a hundred men is considered. Pack animals have not thus far been accepted as entirely satisfactory; horses or mules are all right if they do the work, but they will get stalled in the mud, hung up in fallen timber or brush, and scared and stampeded in a fight. Now, why not the burro?

The burro seldom stampedes at anything; he will stagger along under a load of half his own weight; he can climb over, through or under timber or brush that would stop almost any horse or mule, and if he gets stuck there or in the mud, his small bulk and weight permit his release by two or three men; and finally, if some hostile bullet finds in him its billet, the pecuniary loss to the service is very small and is easily replaced. Aside from his value under fire is his everyday usefulness on campaign.

I would advocate attaching three ordinary burros to every full company of infantry, requiring some two men to care for them in camp and to herd or lead them on the march; to feed them when there was any feed to be had, or help them to forage, as they would frequently have to, for any food they obtained. On the march each burro would carry from twenty to twenty-five pounds of reserve ammunition, enough in the aggregate to materially help the company withstand an attack until communication could be opened with the ammunition train. Among the three could be divided the company officers' baggage and mess outfit, amounting to say 25 or 30 lb. each.

A good donkey can jog along all day in total unconcern under 70 or 75 lb. of load; we therefore have an unemployed available carrying power of from 30 to 25 lb. which I would employ to help out another military difficulty that is always with us—viz., the matter of intrenching tools. I do not suggest placing all the intrenching abilities in this outfit; every man should carry always with him a good strong trowel, in his belt or, as one inventor proposes, set into and forming part of his gun-stock.

Give the present heavy expensive ordnance "hunting knife" and scabbard to the board of foreign missions for the heathen; it is neither knife, intrenching tool nor anything else useful. Relieve the soldier of its weight and give him a trowel—not a trowel bayonet, or a combination trowel and undershirt, two in one—but just a plain, strong, cheap, twenty-five cent trowel with which the possessor can lie flat on his belly and burrow. Under fire, that is just what he needs, but how often has it occurred that the immediate availability of a few picks and shovels or spades, always in the quartermaster's trains and perhaps miles away, might have enabled an inferior force to use a few minutes before actual fire contact in intrenching so well as to change a retreat into a successful resistance? I would, therefore, advocate placing a few axes, pickaxes and spades—light, but strong and serviceable—on the three company burros, where they would be always available.

In coming into action off would come the loads—the tools for use, officers' baggage to look out for itself, the extra ammunition for distribution—and the donkeys, cleared for action, would make a bee line for the ammunition train, and return with a load each of cartridges through and over country probably impracticable for wheels, which was the case in a great majority of battles in the war of the rebellion. When not bringing up ammunition or returning light, our burros could be of greatest assistance to wounded men in getting them to the nearest field hospital on their backs or by means of pole litters, or possibly travois.

In camp or in winter can tonments the burros would be of greatest utility for packing wood and water, in policing, carrying away refuse and assisting and relieving the men in many ways.

With troops in garrison in time of peace, it would probably be advisable to keep only a few burros at a post for pack drill purposes, while the supply for the service would be concentrated at large depots and breeding stations, with many square miles of the public lands for grazing purposes and where the cost of support would be almost nothing.

To supply companies in service with the outfit proposed would be cheap to absurdity; its maintenance in service would be very inexpensive, and the writer is confident that this plan would secure a service with reference to an immediate and continuous supply of ammunition to the firing line and tools for intrenching on emergency, the results of which in any one encounter would probably much more than pay the small expense incurred, and which seems to him to be more practicable than any scheme for the purposes involved of which he has yet heard.—Journal of the Military Service Institution.

ASPHALTIC CEMENT.

THE adaptability of asphalt for different purposes cannot be ascertained by destructive distillation, as the products of destructive distillation vary with the material and process used. Temperature, pressure, time, presence of different substances, manner of condensation and probably electricity, all tend to vary the products of destructive distillation.

Ultimate analyses do not give a correct idea of the characteristics and properties of these substances, as the asphalts are composed of carbon, hydrogen and oxygen in uncertain amounts, and polymerism is confusing.

In asphalt there are three principles sufficiently distinct to be easily separated by several known solvents. These principles do not exist in asphalts in defined proportions. By the existing proportions of these principles, partly if not altogether, can be determined the adaptability of the asphalt to different constructions and purposes.

The three principles contained in asphalts and separable by known solvents are:

1st. A yellow resin, sometimes reddish brown, soluble in absolute alcohol.

3d. A brownish black resin, soluble in ether and insoluble in alcohol. These two principles taken together are known as petrolene.

3d. A black substance, brilliant, having a conchoidal fracture, dissolving neither in alcohol nor in ether, but which does dissolve perfectly in chloroform, bisulphide of carbon and spirits of turpentine. This principle is known as asphaltene.

PETROLENE.

This principle is known as petrolene on account of its being always an essential ingredient of petroleum. It is of a brownish black color, and of a soft and glutinous consistency, of a bituminous odor and has but little taste. It burns with a white flame, giving forth much soot. It boils at 536° F. It is lighter than water. It is composed of carbon and hydrogen.

A highly concentrated solution of soda or potash, when hot, dissolves the brownish black resin of the asphalts. If some diluted sulphuric acid is poured into the liquid, a brown gelatinous substance is precipitated.

ASPHALTENE

is solid, hard and fragile, a brilliant black substance, breaking with a conchoidal fracture. It burns like resins in general, leaving a very abundant coke. When pulverized, it presents sometimes a mass of purple color, oftener of a brownish red. Develops by friction resinous electricity. It has a density greater than water. It melts at 314° F. Analysis has disclosed in it a large amount of oxygen. It is considered that asphaltene is produced by oxidation of petrolene. It is composed of carbon, hydrogen and oxygen.

Asphaltene is not sensibly affected either by caustic potassa or caustic soda in a concentrated solution in water.

ASPHALTUM

is composed of carbon, hydrogen and oxygen in uncertain amounts, and also there is sometimes found chemically combined sulphur, in undefined quantities, in nearly all of them, and nitrogen in some. Their chemical composition is as follows: Carbon 76 to 87, hydrogen 6 to 13, oxygen 2 to 10, and sometimes sulphur 0 to 10, nitrogen 0 to 13.

The peroxides of heavy metals decompose asphalt under the effects of high temperature into water and carbon.

When heated in a current of oxygen, naphthas undergo a quick change and turn into that brownish black resin which is soluble in ether.

When naphtha is left for a long time in the presence of oxygen gas, and in the light, they absorb this gas, some carbonic acid is set free, water is formed, their odor becomes weaker, they likewise become viscous, while they assume a darker and darker color.

It is highly probable that the asphalts of California and some other places were to a considerable extent oxidized at their formation, that is at the time of their distillation from carbonaceous material contained in shales and rocks, this distillation being effected by chemical heat in the presence of water. When first distilled, and while ascending to the surface of the earth, or before they became exposed to atmospheric influences, they were diluted and associated with a large quantity of volatile hydrocarbons. Upon exposure to the atmosphere and light they were further oxidized, and the volatile oils were evaporated. By continuous exposure to atmospheric action it becomes viscous and black, and can be drawn out into long round threads. Then it gradually changes from this state to one of ductility without viscosity, black, and with some luster, and shades with dark green when sulphur is one of its constituent parts; then, in the course of several years, to hardness and brilliancy. If the impurities are large, the mass becomes resonant. Up to this time it is of a close compact texture, and its specific gravity has increased. From this point it gradually becomes porous and its specific gravity decreases, then it begins to slowly turn to a brown color, slowly losing its brilliancy until, after a long number of years, it loses its luster, becoming a light brown and friable and can be easily ground to an impalpable powder between the fingers. There is no well marked line between these conditions, but they progressively and imperceptibly emerge from the one below into the one above. The transition from the viscous to the brown state requires a long time; at first it is comparatively a quick action, gradually decreasing, until it becomes exceedingly slow.

The amount of petrolene diminishes during these changes. There is not merely a loss of petrolene during these changes, but a chemical change. It cannot be restored to its former viscous or ductile condition by the addition of petrolene or other tempering materials; the change is permanent.

To illustrate this atmospheric action, the following familiar performance of drying oils under similar circumstances is given:

When siccative oils, which are readily oxidized by any of the usual oxidizing reagents, are used in painting and exposed to the atmosphere they first become sticky, then gummy, then hard, with some flexibility; then, after long exposure, hard, and finally, after very long exposure, they commence to fall away in an impalpable powder.

The addition of the thin parts of oil, similar to that which they formerly contained, will not restore them to a viscous condition, such as they possessed before exposure to the atmosphere. The air has chemically destroyed their properties and nothing can restore them.

If air be excluded, the fixed oils may be preserved unchanged for a lengthened period, but they change, as above stated, under exposure to the air. Under certain conditions, as when cotton waste, shoddy or hemp is moistened with oil and exposed to the air, oxidation of the oil becomes so energetic as to lead to considerable elevation of temperature and even actual inflammation.

Asphalt deposits, whether the overflow from tar springs, bitumenized sand argil or limestone or other materials impregnated with bitumen, all show the asphalt in its numerous degrees of chemical change. Where they have been exposed to the air for a long time, the bitumen is brown and friable; where not so much exposed, or exposed for a shorter time, they are black and fragile; for a still shorter time or less exposed, ductile without viscosity; for a very short time, viscous; and where there is but little or no exposure they are generally held in solution by volatile and liquid hydrocarbons and are liquid.

Upon the presence of petrolene largely depends the viscosity, ductility, toughness, tenacity, plasticity and cementitious value of asphaltic cement.

But it is found that adding petrolene to asphalt, in which it is deficient, does not restore or renew the properties which have been lost. This shows that the absence of petrolene is indicative of changes which have gone on in the whole of the bituminous constituents of the asphalt, rendering it hard and brittle. No addition of petrolene will give to brown and friable asphalt any cementitious value. It is lacking in toughness and tenacity, and will not pull out into long threads. The process of hardening of the asphalt seems therefore to be connected with a chemical change in the petrolene.

The more petrolene there is present, the softer and tougher is the asphalt; and, as a chemical change goes on and converts it into a harder and less volatile substance and makes it less soluble in ether, the less yielding and more brittle the pitch becomes.

The further this chemical process of hardening and turning brown has progressed, the less capable the

asphalt is of being restored to its original toughness and tenacity by the addition of petrolene.

The restoration of brown, friable asphalt is impossible. Petrolene does not assist it to any great extent. When the asphalt is ductile and black, and this chemical alteration is slight, by the addition of petrolene it makes a good asphaltic cement. The mixing of hard asphalt and petrolene or other softening material is never complete. Take a certain quantity of red powder and an equal quantity of white powder, both reduced to exceeding fineness, it is a long and tedious task to mix these powders so as to produce a pink powder. So the intimate mixing of hard asphalt with viscous materials is not accomplished even after long manipulation and stirring.

Petroleum oil, when converted to asphalt by oxidation, cannot be restored to petroleum oil by any known means.

The hardness of asphalt is dependent upon the amount of asphaltene present. The presence of asphaltene is necessary in most constructions. It gives the petrolene body.

The greater the amount of petrolene, the lower the softening, flowing and boiling point of asphalts.

The greater the amount of petrolene, the smaller the specific gravity.

In testing the comparative solubility of asphalt in different solvents, they behave in very different ways, and it appears that the substances resulting from solution with different solvents possess properties differing widely from one another. This fact becomes especially noticeable in successive treatments of asphalt with alcohol, ether and chloroform.

The manner of extracting these principles is as follows:

The specimen of pavement, asphaltic cement, bituminous rock, asphalt, etc., is first weighed, then heated in a suitable flask to a temperature of 212° F., to expel all moisture, then weighed. The difference between these weights gives the amount of moisture and volatile hydrocarbons expelled. Neither the moisture nor volatile hydrocarbons are of any value in construction; in fact, they are injurious.

It is then treated with chloroform, the solution decanted from the dross; and this operation repeated as long as the chloroform acquires any tinge of color. The bituminous solution is then distilled, so as to remove all the chloroform. This is done in a cup or flask of known weight and specific gravity. If this mode is pursued, the weight and specific gravity of the separated bitumen can be readily ascertained without removing the sticky or hard bitumen from the cup in which it was evaporated, and to which it is probably strongly adhering. The weight of the cup is subtracted from the weight of the cup and bitumen, and the remainder gives the weight of the bitumen.

Subtract the weight of the extracted bitumen from the weight of the specimen which had been ascertained after heating the specimen to 212° F. This will give the relative amount of bitumen and dross.

The impurities can also be weighed after the chloroform has been evaporated, to verify the difference of weight between the bitumen and dross.

The specific gravity of the separated bitumen held in the cup can be ascertained if desired.

To drive off all volatile matter not valuable in most construction and which cannot consistently be regarded as petrolene, let the bitumen be exposed to a temperature of 275° F. for ten hours. This number of hours is only conventional, but is sufficient to eliminate all valueless hydrocarbons. This heat can be maintained by means of an oil bath.

The melting and flowing points and specific gravity can be ascertained at this point of procedure, if desired. Then proceed as follows:

CONSTITUENTS OF ASPHALT SOLUBLE IN ALCOHOL.

A small known quantity of bitumen which has been purified by aid of chloroform (pulverized, if hard) is treated with boiling alcohol of a specific gravity of 0·835. The yellow colored solution is decanted from the residuum before cooling. The residuum after cooling is again pulverized, if hard, and the bitumen again treated with boiling alcohol, and this operation is repeated as long as the boiling alcohol acquires any tinge of color. The materials extracted by the alcohol are poured together when hot, and the alcohol is removed by distillation and there remains a yellow, oily substance having a very strong bituminous smell. This is but slightly soluble in cold alcohol, more readily in boiling alcohol, readily in ether, benzol, chloroform, spirits of turpentine and bisulphide of carbon. When heated, liquid products of decomposition appear, while a small amount of carbon remains.

When the solution in alcohol of the yellow resin-like principle is treated with liquid ammonia, it produces an abundant white precipitate.

CONSTITUENTS OF ASPHALT SOLUBLE IN ETHER.

The residuum left in the treatment with alcohol is treated with boiling ether of a specific gravity of 0·725, in a manner similar to that described for performing the extraction with alcohol. After the removal of the ether by distillation, there remains a brownish black, resin-like, brittle mass. It is almost odorless and usually begins to melt at 65° C.

This substance is insoluble in cold or boiling alcohol, but is readily soluble in the other solvents of asphalt. Carbolic acid dissolves it without residue. The diluted solutions have a brownish yellow color, with a greenish fluorescence.

The fat oils behave with asphalts as ether does. They dissolve only the black brown resin, while they leave the asphaltene.

The substance extracted by alcohol and ether when combined is known as petrolene. If the main object is to ascertain the amount of petrolene present, the treatment of the asphalt with alcohol can be omitted, and the extraction of petrolene from the asphalts can be made with ether alone.

CONSTITUENTS OF ASPHALT INSOLUBLE IN ALCOHOL OR ETHER.

The portion which remains insoluble in alcohol or ether is a resin-like mass, very brittle, with a brilliant black luster and without odor, usually having a melting point at 156° C. It is readily soluble in chloroform, spirits of turpentine, bisulphide of carbon. The diluted solutions of it have a brownish yellow color with a green fluorescence.

The solution in chloroform is precipitated with ether. It is called asphaltene.

TABLE SHOWING THE AMOUNT OF PETROLENE AND ASPHALTENE IN SOME OF THE ASPHALTS.

Name of Asphalt.	Bitumen.	
	Petrolene: soluble in ether.	Asphaltene insoluble in ether.
Bechelbrown	85	15
Jew pitch, Dead Sea	75	25
Cexitambo	5	95
Syrian	48	52
Lake best, Trinidad	70	30
Lake average, Trinidad	63	47
Soil, Trinidad	47	53
Chocolate pitch, Trinidad	49	51
Iron pitch, Trinidad	64	46
Asfalto, California	52	48
Glance pitch, California	7	93
Bitumenized sand, California	93	7
Bitumenized argil, California	80	20

As far as experiments have progressed, 80 to 85 per cent. of petrolene and 15 to 20 per cent. of asphaltene would be the proper proportions for a cement for street pavements, employed in combination with sand and limestone. The combination in these proportions would not be too hard in the extreme of cold in winter or too soft in the extreme of heat in summer, temperatures to which the pavement may be subjected, thus guarding against the breaking of pavements in the winter or their ready deformation in summer, when the same are exposed to traffic.

A cement employed in the construction and coating the sides of a reservoir should be sufficiently ductile to follow any subsidence of its embankment without cracking, but not so soft as to flow or distort in hot weather, should contain 25 to 30 per cent. of asphaltene; and, if the slopes are very steep, even as high as 40 per cent.

In the manufacture of varnish there should be from 85 to 90 per cent. of asphaltene, as the presence of any considerable amount of slowly drying petrolene would keep the varnish sticky for a long time after the volatile vehicle in which the asphalt is dissolved to make the varnish has evaporated.

Other purposes requiring asphaltene and petrolene in different proportions could be enumerated, but the above is sufficient to illustrate.

The majority of the asphalts of commerce are deficient in petrolene. To supply this deficiency the following described substitutes for that principle have been tried.

In making asphaltic cement, volatile petroleum oils have been employed to supply the deficiency of petrolene in some of the asphalts. This makes a cement of short life, for as soon as the oils are evaporated the cement becomes of the same hardness as the asphalts were before they were softened by these oils.

Animal and vegetable oils and fats have also been used for tempering asphalts. Evaporation and decomposition soon destroyed these masses.

By the application of heat these worthless admixtures can be determined.

Coal tar has been used to soften the asphalts so as to form a cement. It is hard to obtain a uniform quality of coal tar. Some are full of soot, coke and naphthalene, while others contain large quantities of volatile oils, all of which are decidedly deleterious in their nature. These undesirable qualities do not make a durable cement. A pavement made of this cement seems too soft in summer, but in winter excessively brittle. When subjected to atmospheric influences, a rapid oxidation as compared to the oxidation of true asphaltic cement takes place, by which it loses its cementing qualities and becomes inert. The particles of sand then lose their adhesiveness and the pavement rapidly disintegrates. In hot weather it diffuses a disagreeable odor. Wherever laid, pavements containing coal tar have as a rule given little satisfaction. The presence of coal tar can be detected by its odor when heated.

Coal tar is a bitumen known as a nitrogenized mineral tar. When it is softened by the heat of the hand it can be stretched out into flat striped threads, short and fragile, while the practically non-nitrogenized asphalts under similar treatment develop into round threads which reach to a great length and run out to extreme fineness.

In place of petrolene the residuums or still bottoms of petroleum oil have been used. These residuums are composed of lubricating oils, impurities, coke, but principally of soft and hard paraffins.

The paraffin contained in residuums or still bottoms is a mixture of various hydrocarbons of different specific gravities and boiling points. Its specific gravity varies from 0·823 to 0·940. Paraffin is insoluble in water, slightly soluble in alcohol, freely in ether, and miscible in all proportions when melted with both fixed and volatile oils. Paraffin has a melting point varying from 16° C. to 80° C. The paraffin scale separated from oil of 0·905 specific gravity has an average melting point about 125° F., and that from the oil of 0·885 specific gravity a melting point of about 117° F.

At a considerable number of degrees below its melting point it becomes soft and plastic. For instance, paraffin fusing at 125° F. may be easily bent and twisted into any form at a temperature of 90° F. It begins to decompose when exposed to a temperature exceeding 280° F. When submitted to dry distillation, a portion of the paraffin is decomposed into liquid hydrocarbons.

In most commercial asphalts chlorine is present in considerable quantities. When the asphalt and residuums are heated together, the paraffin in the residuum is acted upon by the chlorine, the hydrogen in the paraffin being replaced by that element and hydrochloric acid evolved. When the action of chlorine is continued a hard, brittle resin is the result.

Nearly all the asphalts of commerce contain sulphur in combination. When these sulphurized asphalts are heated with residuums, the paraffin in the residuum is decomposed, sulphureted hydrogen being evolved and and carbon deposited. The presence of ammonia would probably arrest part of this decomposition.

The presence of coarsely crystalline paraffins in the cement, making it very susceptible to changes of temperature, causing it to become soft under the hot summer sun and brittle at or below frost, is undesirable, since they impart to the asphalt cement similar properties and make it liable to scale in winter if made hard enough for summer.

The presence of much light oil renders the cement liable to change if it is kept in a melted condition for a length of time, or exposed to atmospheric influences.

The usual commercial asphalt and residuum oil are of very different specific gravities, the first being considerably heavier than water, having at 325° F. a specific gravity of 1·11, while the oil is considerably lighter than water, having a specific gravity of 0·94. At the same time the bitumen of asphalt is not very miscible in petroleum oil. The result is that a vast amount of mechanical agitation is necessary to make a homogeneous mixture of those two bodies, and if such an end is not accomplished, the cement is not even, some parts being softer than others and no portion being homogeneous in itself. This is fatal to good asphaltic cement, when used in a pavement. The surface will then inevitably roll out of shape and into waves.

These residuums being so variable in character, their miscibility with asphalt being so difficult, the susceptibility of the hard paraffins and light oils to differences of temperature, the chemical reactions of the paraffins in the presence of sulphur, chlorine and other mineral ingredients caused by the heat used in mixing the residuums, oils and asphalt, make it extremely difficult to obtain asphaltic cement of a uniform character by substituting residuums for petrolene.

The asphalt that naturally contains petrolene and asphaltene in proper and required proportions is the best for all purposes.

A. S. COOPER, C.E.

Santa Barbara, August 30, 1894.

THE SUGAR INDUSTRY.

IT is easy to believe that the sugar beet will be of inestimable value to the country, and form part of a successful agriculture that will solve the problem of the industrial status of this great area. It will also promote political peace by establishing the prosperity of the people on a firm foundation. I have seen much of the arid district east of the Rockies for the last fourteen years, having been engaged in the cattle business from Texas to Montana; and the present condition and future possibilities of settlement in this section are constantly before my eyes. Only within the last few years has the necessity of irrigation to the eastward of the Colorado line become manifest; but it is now coming, and with it the population that will need this new branch of agriculture.

Next, I feel that the larger portion of farmers in this section need the training and education that will be brought by the sugar beet. We must adopt all possible means to avoid sinking into stolid and unthinking peasants, and must compete with other countries by brains and industry, and not by simple endurance of poverty. In the future some time our section will be the seat of beet sugar production, and, once established, our best protection will be the cost of transportation into the mountain and upper Missouri district. This brings us to the important point of cost of transportation to the trans-Missouri country. The price of the commodities we sell is settled at Chicago or London, and we pay the freight charges to market; which charges are 50 to 100 per cent. of original value. The price of the commodities we buy is settled at Boston or New York, and we pay freight charges to the West.

We should have a chance to make a start and begin to learn something about sugar beets now; and none but those who have experience know how much there is to learn and how hard it is to learn it. The sugar beet is the most artificial and scientific of all products of agriculture, and in every country where produced, capital and energy have been needed to sustain the production by farmers. The original cost of a factory, added to the amount that is likely to be lost in beet growing on a large scale for the first season or two; and added to this the cost of organization, salaries of experts in and out of season, cost of wear and tear of agricultural machinery, and cost of farm animals, make a total that only a strong financial combination can stand.

It is not like other branches of agriculture, in which the simple crops of wheat, oats or corn have been planted for an unknown number of centuries. The farmer inherits these crops, and will plant as naturally as he eats, whether they will grow or not. It is pathetic to see, for the last decade, corn fields along the Union Pacific at an elevation too great for this crop, and which yield about as successfully as would cotton on the same land. Farmers will not take hold of sugar beets except under the protection of a strong friendly organization that will grow beets themselves and show them how.

The culture of beet seed alone is the care of a lifetime to scientific growers in France and Germany; and in the development of this one single branch is to be found justification for a bounty, and for the foundation and maintenance of experiment stations for continuous investigation and improvement of species.

We are fortunate indeed that two of the most intelligent and civilized nations in the world have spent the best part of this century in the discoveries that open to us so wonderful an industry as that of beet sugar. We have merely to examine the results in those countries to find out whether we want it here or not, and this any one can do with very little pains. One of the inevitable results of beet culture will be to multiply the population greatly in the beet districts, and eventually reduce the size of farms. It will make it possible to get the support for a family from twenty or ten acres of land, as proved by the gross value of the crop per acre.

The average value of a crop of corn per acre is about $10 in this fertile section, and some of our land in beets this year yielded a gross product of $125 per acre, which shows how many more people can be supported by growing beets than by growing corn. Another valuable point is that the manufacture of sugar will help

to furnish employment to idle laborers, and to my mind nothing is to be more deplored than the present enforced idleness of so many men from December to April.

Our land, now worth (in this section of the State) $25 to $40 per acre, will reach a value of $125 to $250, and buildings will be multiplied a hundredfold. The two sugar factories in Nebraska to-day stand nearly alone as evidences of a higher industrial and social life in the future. And taxable values will be multiplied and yield a revenue that can be applied to the improvement of the condition of those who till the soil.—Chino Champion.

[FROM THE ENGINEER, LONDON.]

MAXIM'S FLYING MACHINE.

THE success which recently attended Mr. Maxim's endeavors to propel a machine through the air is so marked that we think a description of this most remarkable contrivance will not just at present be out of place. It is not to be supposed for a moment that this machine approaches anything like perfection, but there can be no doubt that its performances considerably eclipse all previous efforts. Through the courtesy of Mr. Maxim we are enabled to here reproduce a view of the machine in flight; also a table showing the lifting efforts. The remaining diagrams are our own, and illustrate the principles of various devices which we shall proceed to describe; but before doing so we shall briefly glance over the occurrences of July 31 last, on which occasion the soaring tendency of the machine became so great as to overcome all the obstacles which were designed to retain it near the ground, and Mr. Maxim found himself in a somewhat similar position to that of Frankenstein when overpowered by the monster which he himself had fabricated and endowed

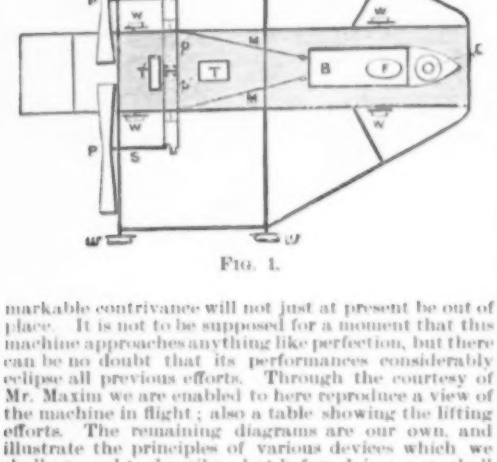
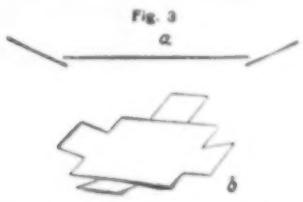


FIG. 1.



with life. This is what happened: The machine had traveled some 1,000 ft., the latter 550 ft. of which it had flown, a fact which is clearly proved by the impressions made on the inverted guard rails. It appears that suddenly the lifting effort became so great that the framework carrying the after retaining wheels became distorted to such a degree that the wheels ceased to perform their office, and the afterpart of the machine became free; the forepart, however, continuing to hold the machine down, but not for long, as the wobbling which ensued rendered steering impossible, and the machine got out of line with the track. The left-hand front wheel also got free and the machine charged against one of the timber supports carrying the right-hand guard rail, tore up the rail, which is simply a 9 in. by 3 in. plank, and did very great damage to its own framework. The ride was in this way brought to a sudden stop, and it will be several months before it can be renewed. The total weight of the machine, including 600 lb. of water, 300 lb. of naphtha and three men, was about 8,000 lb.

Fig. 1 shows the deck plan of the machine. P P are the two propellers mounted on the shafts, S S, to each of which motion is given by a compound steam engine, B is the main boiler, delivering steam through the pipes, M M. G is the gasoline boiler, which is kept charged with about 40 lb. of naphtha by a pump, p', automatically regulated, the supply being contained in the tank, T', while the larger tank, T, contains the feed water, which is fed into the boiler by the feed pumps, p. W W W W are the wheels which run on the track before the machine has commenced to soar, and w w w w are those which were supposed to retain the machine by reason of the inverted rail above them. This they failed to do, owing to the too slender construction of the framing in their vicinity.

Above all this there is the great central aeroplane, with a surface of some 1,400 square feet. This, with the side wings and the steering planes fore and aft, all taken together, have a total area of 5,400 square feet. At the time of the trial the area was 4,000 square feet, as six of the side planes were found unnecessary. Our view, Fig. 2, shows the machine as it was at the trial. The total width is 104 ft. and the length 125 ft. The angle of the steering planes, which is about 7·25°, or 1 in 8, is controlled by a steering windlass, which when soaring turns them, very slightly, opposite ways, as a in Fig. 3, when the machine would soar whichever way it was being propelled. The total lift of the planes amounts to 10,000 lb.

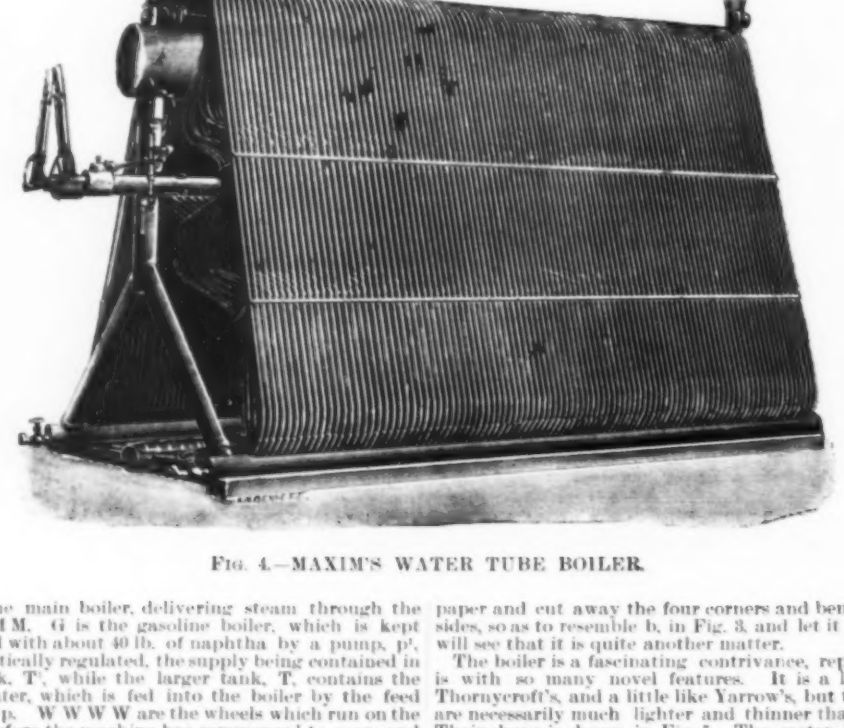


FIG. 4.—MAXIM'S WATER TUBE BOILER.

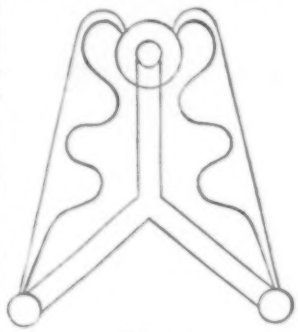
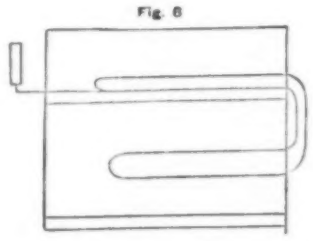


FIG. 5.



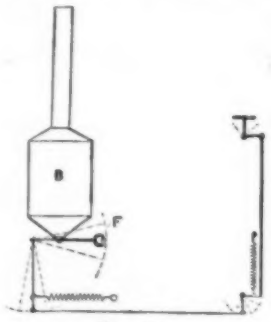


FIG. 7.

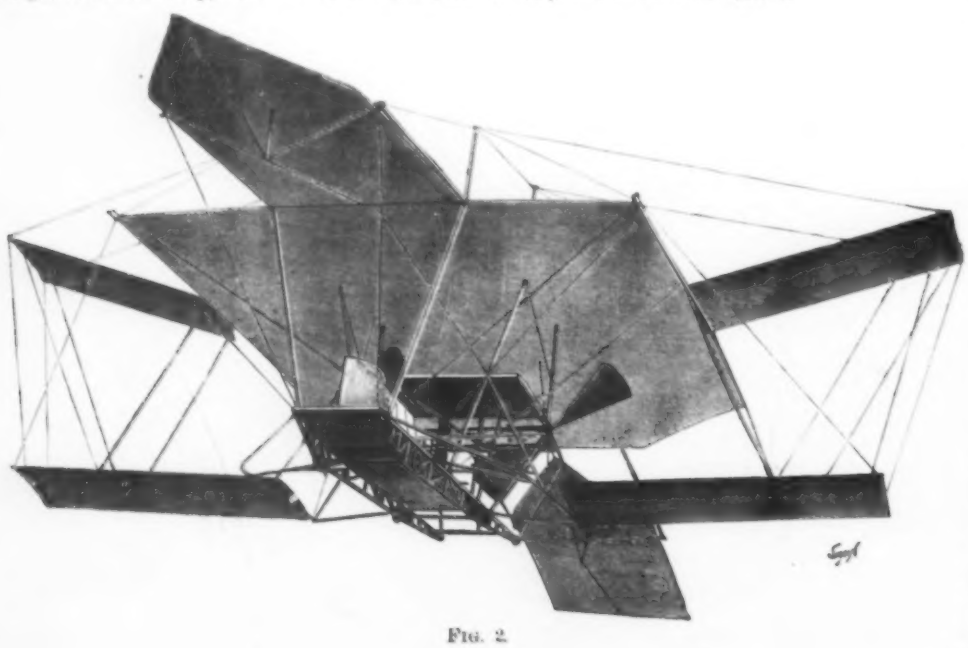


FIG. 2.

Another valuable property of these fore-and-aft aeroplanes is their tendency to preserve the equilibrium of the machine in descent. To understand this, let the reader take a sheet of paper, hold it some 6 ft. off the ground, and observe how it dives to the ground on being released. Now let him take the same piece of paper and cut away the four corners and bend up the sides, so as to resemble b, in Fig. 3, and let it fall. He will see that it is quite another matter.

The boiler is a fascinating contrivance, replete as it is with so many novel features. It is a little like Thornycroft's, and a little like Yarrow's, but the tubes are necessarily much lighter and thinner than either. Their shape is shown in Fig. 5. The water boxes at the bottom are 2½ in. in diameter and 1½ mm. thick. The water tubes are of copper, and about ⅛ in. thick. The total heating surface is about 800 square feet, the flame surface being 30 square feet. The Y downtake is 3 in. in diameter. There is a forced circulation maintained by an injector in the upper leg of the inverted Y. This may be briefly explained as follows:

Water is pumped into the boiler at 330 lb. per square inch. This escapes into the boiler through an injector nozzle, and as the steam pressure usually required is 300 lb., it follows that there are 30 lb. devoted to this circulation. The cold water coming in combines with the hot water, increasing the gravity of the water in the downtake, and down it goes, so that the water coming in is immediately taken to the hot tubes. The nozzle is provided with a spring which always maintains the 30 lb. difference in pressure. A very convenient apparatus is attached to the feed pipe, by

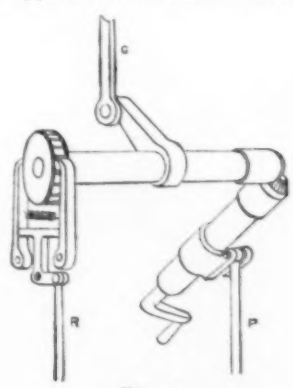


FIG. 8.

which it is possible to see at a glance exactly how many pounds of water per hour are entering the boiler.

A novel way of observing the height of water in the boiler is a thermostatic gauge, the principle of which we endeavor to show in Fig. 6. A gauge communicates with the interior of a bent tube, which is a boiler in itself. Its lower half is exposed to the flame of the furnace, the upper half lying in the drum below the water level, and as long as this half is immersed the water within it will be at the same temperature as that in the drum, and therefore at the same pres

sure. But if it is exposed, the pressure rises enormously, and consequently, the needle also, and it is known that the water is low. There are no glass water gauges on the boiler, as this device supplies all that is wanted.

Over the upper part of the boiler there is a second

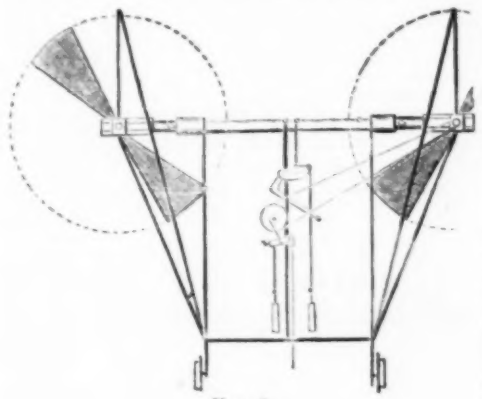


FIG. 9.

system of smaller tubes, also of copper, $\frac{3}{4}$ in. diameter and $\frac{1}{20}$ in. thick, constituting the feed water heater, which raises the temperature of the water to 250 deg. Fah. In this way the products of combustion having passed between the boiler tubes are brought into contact with the incoming water before escaping.

The boiler will and does make more steam than can be used. Its weight with its feed water heater, casing, uptake, furnace, and water is 1,300 lb., 200 lb. being that of the water itself. The fuel employed is naphtha

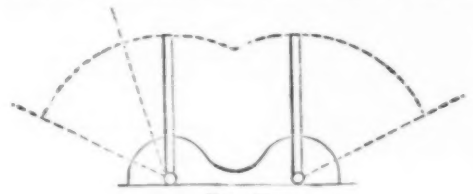


FIG. 10.

of 72 deg. Baume. This is heated in the gasoline boiler by a part of its own contents, and delivered to 7,650 jets at a preasure of 50 lb. per square inch. The average contents of this boiler is about 40 lb. Figs. 7 and 8 show the devices by which an automatic regulation of its supply is obtained, which is found perfect.

It will be seen that the gasoline boiler is supported on one arm of a bell crank lever, which is balanced with spiral springs, so regulated as to keep it floating when containing 40 lb. of naphtha. The entire generator and contents weigh 100 lb. If the boiler becomes overcharged, the increase in its weight sets in motion a system of rods and levers terminating at rod, R, in Fig. 8. P is here the gasoline pump rod, actuated by one arm of the rocking lever which derives its motion through the connecting rod, C, from a crank-shaft driven by belt and pulleys off the port propelling engine. The rod, R, in actuating the bell crank lever—one arm of which is shaped like a T—throws in or out of gear either one or the other of the fixed pawls which engage with the ratchet wheel, which in its turn, by means of bevel gearing, increases or decreases the radius of the arm to which the gasoline pump is linked, according to the direction of the ratchet feed.

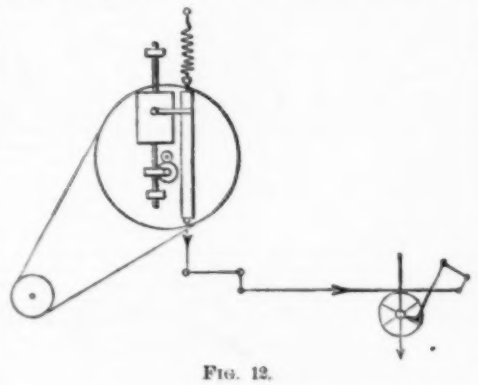


FIG. 12.

The gas, when generated, passes through the furnace and then out at the other end of the steam boiler. It then enters the burner through an injector, and the fall in pressure from 50 lb. per square inch to 1 lb. per square inch is made to do work in sucking in air. A damper-shaped valve may be turned about so as to vary the air at will—full on blows the gas out, while with it closed, a great cloud of black smoke is given off at the smoke stack. With a proper adjustment the flame is a purple white, and about 22 in. high.

The engines are 363·63 horse power, and drive the screws—which are 17 ft. 10 in. diameter, each having two blades 62 in. wide, with a 16 ft. pitch—at a speed of 375 revolutions per minute, driving the machine at 40 miles an hour. Mr. Maxim estimates that 130 horse power is wasted in slip, 133·33 expended in actual lift on the angle of the aeroplanes, and 80·30 in driving the machine, its frame and wires, through the air. The screw thrust before starting has been found to be 2,100 lb.—while running, 2,000 lb.

The engines are beautifully constructed; their position, with relation to the platform of the machine, can be seen by referring to Fig. 9, which shows the methods adopted in working the pumps. The feed pumps are driven from the low pressure cylinder tail rods by means of bell crank levers, the gasoline pump by means of a pulley mounted on a second crank shaft, which we have already mentioned. The feed pumps work very fast, and pounding is prevented by a rubber bag on the suction very near the pump and spring pistons in the discharge. The quantity of discharge is regulated by varying the stroke by means of the hand lever shown. An indicating check valve shows exactly how much water is entering the boiler, the marking being in pounds per hour.

The engines weigh 600 lb.; so that Mr. Maxim obtains more than 1 horse power for every 2 lb. of weight—which is in itself an achievement. The pumps weigh 100 lb.; the high pressure pistons are 5·05 in. in diameter; the low pressure 8 in. in diameter by 1 ft. stroke. The high pressure cut-off is at 0·75 of the stroke, that of the low pressure being at 0·625. The relatively high pressure in the low pressure cylinder is due to its earlier cut-off and to a large clearance in the high pressure cylinder, which is allowed in order to protect the cylinder from injury by water in case the machine should pitch. The ports and steam passages are unusually large. Piston valves are used with 3 in. travel. The engines move with very little friction, owing to their exceeding lightness. The piston speed is estimated at 750 ft. per minute.

An instance of the great care and forethought with which the engines have been planned lies in the construction of the big ends of the connecting rods. The bolts which secure the brasses are hinged on the end of the rod in such a way as to allow of any slight bending, in the event of the strain on the framework of the machine bringing the crank out of line with the cylinder. It must be remembered that the engine, cylinders, frame and rods are entirely made from sheet metal, so that there is every possibility of there being necessity for some such safeguard as this. By-pass valves are provided, so as to allow live steam to pass directly to the low pressure cylinders; thus, if the steam pressure in the boiler should mount too high, it will blow past the high-pressure cylinders, instead of blowing off into the air, and the fall in pressure is made to do work in the exhaust from the high-pressure cylinders, drawing the steam from the high pressure and driving it into the low pressure, thus causing more direct pressure on the low pressure than back pressure on the high pressure. In this way the engines may be made to develop fully 400 horse power. The steam supply is controlled by two regulators, shown in Fig. 10. These levers are also the steering handles for side steering. When going straight ahead, they are both vertical. If it is desired to turn to port, the port handle is turned outward, which slightly checks the steam supply to the port engine, and the machine necessarily turns. If the machine is to be stopped, both handles are thrown over simultaneously to the extreme positions, as shown by the dotted lines. So simple an arrangement as this admits of instinctive action, entailing absolutely no brain effort, and therefore gives the driver more time to think of other things.

The diagram given in Fig. 11 shows what occurred on the day of the disaster. The ordinates show the lifting effort in pounds, the abscissæ the distance in feet traveled. It will be seen that the dynograph ceased to record after a distance of 1,000 ft. had been covered. In other words—this was the point when the crash came. Fig. 12 shows how the lifting effort is registered on the revolving drum of the dynograph, turning once round in 1,800 ft. The pencil traces a line on the paper, which indicates the pressure on one of the axletrees, both of which are fitted with dynographs.

All the framework of this extraordinary machine is composed of hollow tubes. The exhaust from the main engines is conducted through them out at the back of the main aeroplane, in order that the steam may not injure the canvas. The condenser is not yet a perfected detail. It is a luxury, and not essential to the flying properties of the machine. It is, of course, receiving Mr. Maxim's attention. The horizontal angle of incidence in flight is to be maintained by a "gyrostat," which consists of a gyroscopic wheel, rotating, suspended by universal joints, and connected with the two horizontal aeroplane rudders, so as to act upon them instantly—through the well known property of the gyroscope to continue rotating in the same plane—in case there is any tendency of the machine to deviate from the angle of incidence. The whole of the apparatus is stayed by diagonal wire ties.

What Mr. Maxim has done has been to, so to speak, make a bird that does not know how to fly. We believe that the safe use of such a machine will always depend on the skill of the driver. Because we put on skates, we do not expect to be able to skate right away. No more can we expect Mr. Maxim to be able to control this machine efficiently until he has had years of practice. In the same way there are birds who fly well and birds who fly badly. This bird has only just been hatched. Let us hope that Mr. Maxim will not come to grief, "Icarus like," before he is fully fledged.

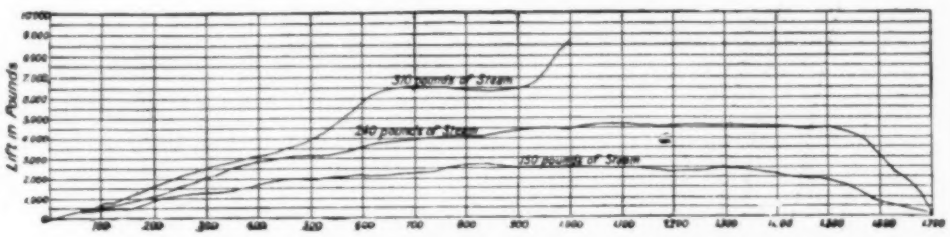
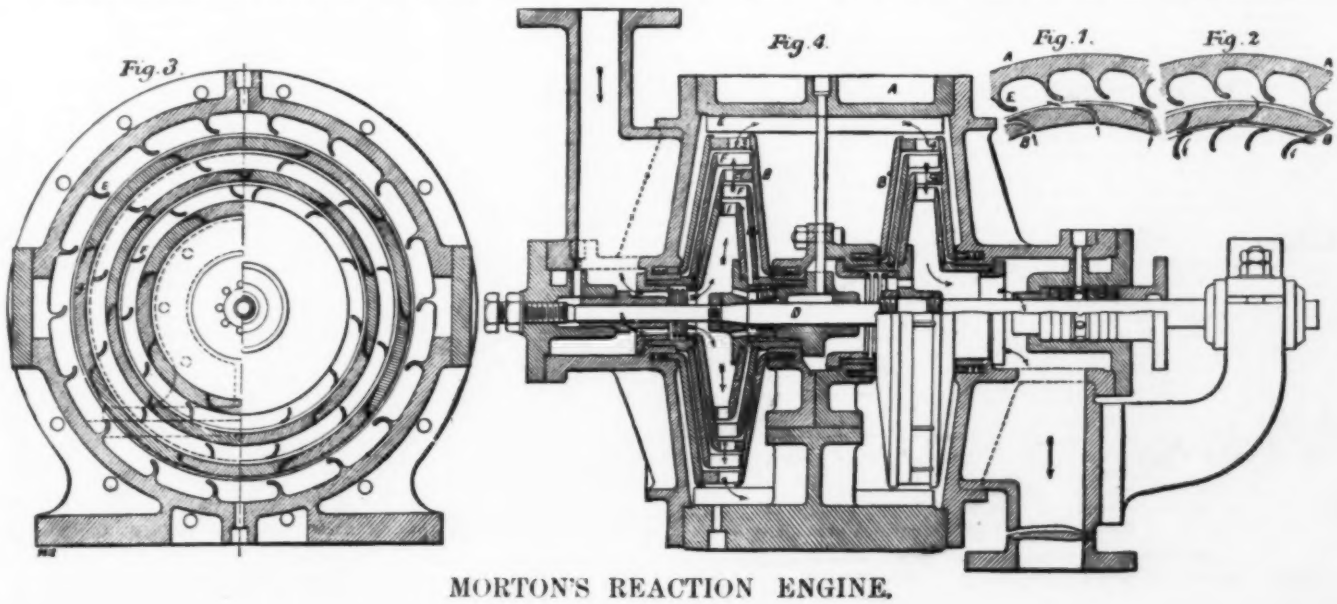


FIG. 11.—DIAGRAM SHOWING LIFTING EFFORTS OF MAXIM'S FLYING MACHINE DURING THREE RUNS MADE JULY 31, 1894.

MORTON'S REACTION ENGINE.

FOR some years Mr. Alexander Morton, of Glasgow, has been experimenting in the improvement of reaction engines, and during the past session he laid his experience before the Institution of Engineers and Shipbuilders in Scotland. Previously, however, he had made very numerous experiments on the flow of fluids through nozzles of different forms, from a higher pressure to a lower, the results of which were embodied in a paper he read before the Philosophical Society of



MORTON'S REACTION ENGINE.

Glasgow. These results were confirmed by Mr. James Brownlie, and described in a paper before the Institution of Engineers and Shipbuilders. The outcome of this work, and of much other that we cannot now refer to, is the engine which we illustrate herewith. The general principle of this engine will be understood from the fragmentary views, Figs. 1 and 2, which show, respectively, parts of an outward flow and of an inward flow wheel. B is a rotating ring, pierced with a number of oblong curved openings measuring, for example, $\frac{1}{2}$ in. by $\frac{1}{2}$ in. at the smallest part, and subject to steam pressure on its inner side. The steam in passing through these openings, and emerging tangentially to the wheel, exercises a pressure on the wheel, which causes it to rotate. To prevent the steam flowing round inside the fixed casing, A, in the opposite direction to the rotation of the wheel, the stationary curved vanes, E, are provided. When there are concentric wheels, the stationary vanes are placed between them, as shown at F, Fig. 2, and guide the steam from wheel to wheel.

The engine, as actually constructed, is shown in Figs. 3 and 4. It has a central shaft, D, carried in three bearings, and capable of endwise adjustment. It is contained within a stationary casing, A, having an inlet for steam at the left, and an outlet to the condenser at the right. Upon the shaft, D, are two sets of wheels, the left hand set being entirely of the outward flow character, and the right set inward flow, the steam passing through them in succession. In the first series there are three sets of orifices, 1, 2, 3, similar to those in Fig. 1. They are formed in brass rings, carried by disks, B, coupled to the shaft and to each other. Between the wheels, B, are the fixed disks, H, carrying the stationary vanes, F, F'. The steam enters around the left hand end of the shaft, D, and, as shown by the arrows, it passes through the orifices, 1, 2, 3, to the fixed vanes, E. The first ring, 1, is 9½ in., the second 12½ in., and the third 15 in. in diameter. The second wheel, B, has two rings of inward flow nozzles, 4 and 5, 15 in. and 12¼ in. in diameter respectively. The steam flows inward through these nozzles, and thence through the exhaust annular opening around the shaft to the condenser. At each ring of nozzles the combined area of openings increases as the steam becomes reduced in pressure. The first ring of the series has eight curved nozzles $\frac{1}{2}$ in. by $\frac{1}{2}$ in., and the last ring ten nozzles $\frac{1}{8}$ in. by $\frac{1}{2}$ in., there being five stages of expansion. This engine coupled direct to a dynamo gave 11 brake horse power. When the low pressure wheel was removed and the high pressure wheel alone in place, the duty with the same weight of steam fell off to 6·5 horse power. With the high pressure wheel removed and the low pressure in place, the duty was 4·5 horse power with the same weight of steam. Dr. Archibald Barr and Mr. H. A. Mavor made a joint series of experiments on this engine, and from their report, the consumption—with steam of 78 lb. pressure above the atmosphere and 20 in. vacuum—was 87 lb. of steam per brake horse power per hour, with feed water at 40·3 deg. Fah.—Engineering.

PROTECTION FROM LIGHTNING.*

By ALEXANDER MCADIE, U. S. Weather Bureau.

AT the Aberdeen meeting of the British Association for the Advancement of Science Sir William Thomson made the remark, "If I urge Glasgow manufacturers to put up lightning rods, they say it is cheaper to insure than to do so."

This was the answer given by practical business men, concerned only with questions of profit and loss, to the foremost physicist of our time; and their answer will serve as fairly representing views widely held, founded upon the double belief that the risk from lightning is not so very great and the protection afforded by the present methods not sufficiently certain to warrant implicit confidence and justify the necessary expense.

The recent remarkable experiments of Dr. Oliver Lodge, in his lectures before the Society of Arts, opposing and to some degree directly contradicting the empirical rules of the Lightning Rod Conference, have given support to the belief that the protection was uncertain. Indeed, realizing that this work might be misinterpreted, Lodge has stated "an idea at one time got abroad that my experiments proved existing lightning conductors to be useless or dangerous; this is an entire misrepresentation. Almost any conductor is probably better than none, but few or no conductors are absolute and complete safeguards. Certain habits of lightning rod practice may be improved, and the curious freaks or vagaries of lightning strokes in protected buildings are intelligible without any blame attaching to the conductor; but this is very different from the contention that lightning rods are unnecessary and useless. They are essential to anything like security."†

What Lodge's brilliant experimental work does show is that the momentum of an electric current cannot be overlooked in a lightning discharge. The old "drain pipe" idea of conveying electricity gently from cloud to earth must give place to the new proposition, based upon recent discoveries, that even draining off must be done in an appropriate way to be effective. To illustrate, the rocks and trees upon a mountain side may influence and determine the course of a mountain stream, but even a good sized channel would not suffice to carry off safely an avalanche, or control the path of a landslide; so with lightning. In the past four years we have learned, through the work of Hertz and others, that when an electric current flows steadily in one direction in a cylindrical wire its intensity is the same in all parts of the wire; but if the current be of an oscillatory character, i. e., a current which rapidly reverses its direction, the condition no longer holds, and if the alternations are very rapid the interior of the wire may be almost free from current. If lightning then be a discharge of an oscillatory character, it may happen that the current down the lightning rod would be only skin deep. The experiments of Tesla and Elihu Thomson with currents of great frequency of alternation and very high potentials open the door to systematic study of discharges such as the ordinary lightning flash. In daily work currents of this type are coming more and more into prominence, and the time is not far distant when the lightning flash will be studied as an electrical discharge of this character. Protection entirely adequate for such discharges will then be forthcoming. Indeed, the reasons why present methods occasionally fail are now understood, and the proper remedies apparent.

And first let us see whether it is cheaper to insure than to provide proper protection. Foreign countries, especially Germany, France and Great Britain, have recognized the importance of obtaining reliable data concerning the loss of life and damage to property through lightning. Perhaps the work of the Royal Prussian Bureau of Statistics* gives the fullest and most detailed accounts of the damage done by lightning in Germany, and the relative injury. Statistics are available for the number of houses struck, the number of fires, the character of the roofing, soil, etc.

In 1891 the Weather Bureau issued to its observers instructions to report at the end of every month the names, with corroborative dates and places, of all persons killed by violent wind-storms, tornadoes, and lightning. During 1890 somewhat similar statistics had been gathered, but the returns were less systematically arranged. In preparing the Weather Bureau lists, observers were directed to examine all daily papers published in their respective cities, consult all local authorities, and make inquiry if necessary. Naturally, where dependence was had upon newspaper items, there resulted much duplication, but in verifying names and dates the duplicates quickly appear and exaggerated reports are easily confined to proper limits.

Mr. H. F. Kretzer, of St. Louis, Mo., has for some years tabulated the number of deaths due to lightning, and has kindly placed his lists at the disposal of the bureau. His sources of information were 192 newspapers, daily, weekly, and monthly. He found for five years, 1883 to 1887, a total of 1,030 deaths caused by lightning, or a yearly average of 206.

This agrees very well with the Weather Bureau records which I have tabulated.

DEATHS DUE TO LIGHTNING IN THE UNITED STATES, WEATHER BUREAU RECORDS.

Month.	1890.	1891.	1892.	1893.
January	..	..	..	..
February	..	..	..	..
March	2	..	..	5
April	6	13	5	19
May	8	22	27	17
June	37	73	74	66
July	55	52	67	73
August	127	34	54	18
September	..	9	15	8
October	..	..	6	2
November	..	..	1	..
December	..	..	2	1
Total	130	204	251	209

Or 784 lives in four years, an average of 196 lives per year.

A glance at the table shows that these lives were practically all lost in five months—April to September—and that in June and July the maximum death rate occurs.

The Weather Bureau records unfortunately do not give information as to the extent of damage to property. To get at something like a fair commercial estimate of the destruction of property by lightning, I have made use of the "Chronicle Fire Tables" for the eight years 1885 to 1892. It is hardly necessary to remark that these tables are compiled from the reports of the fire departments, insurance companies, and the reports of fires in the public press, and represent a high degree of accuracy.

From information contained in these volumes, the following tables have been compiled:

FIRES CAUSED BY LIGHTNING.

Year.	Number of Fires.	Loss on Original Risk.
1885 to 1890 inclusive	2,200	$8,386,826
1891	457	1,355,525
1892	839	2,921,484

Or, in eight years, ending 1892, in the United States, and for the most part west of the Rocky Mountains, 3,516 fires, with a loss of $12,663,835.

It is very evident, therefore, that the damage done by lightning is no inconsiderable matter to be lightly passed over or turned off by replies such as the one given by the Glasgow manufacturers. It is certainly worth while to erect the proper protective apparatus.

Let us look now at the class of buildings most likely to be injured by lightning. The following table shows the number of barns, stables, granaries, churches, and dwellings set on fire by lightning during the years 1890, 1891 and 1892:

Year.	Barns, Stables and Granaries.	Churches.	Dwellings.
1890	363	29	121
1891	290	11	78
1892	495	29	177

During nine years ending 1892, 2,335 barns, 104 churches and 664 dwellings have been struck by lightning.

The question has often been raised whether there exists a periodicity in the number of lightning strokes. Statistics must cover a period of at least twenty years before an answer to this question can be given, but it is interesting to compare the number and kind of buildings struck for the last two years of which we have record.

It is of particular interest to study the geographical distribution of the dwellings and barns struck in these two years. There are some notable increases in certain States, the reasons for which are not at present discernible. Attention is directed to the figures in bold face type in the table of States following.

According to the statistics of the German bureau, previously referred to, the frequency of lightning stroke varies somewhat with the character of the land. Thus, in their investigations it was found that in flat lands 400 to 540 buildings were struck out of 1,000,000, the rate varying in different localities.

	1891.	1892.
Barns, granaries, and stables	280	495
Churches	11	29
Country and general merchandise stores	5	6
Dwellings and tenements	78	177
Electric light stations	1	2
Grain elevators	2	4
Grain fields	1	..
Grain, hay, and straw in stack	10	12
Ice houses	4	4
Lighthouses and life-saving stations (no other source of fire reported)	2	
Livery stables	4	4
Lumber yards	2	1
Oil refineries	2	2
Oil tanks	2	22
Railroad depots	5	7
Telegraph and telephone offices	2	3

The nature of the material used for roofing has also been considered. Classifying the various materials under the general heads "hard" and "soft," the German investigators found for ten years (1873-83) for Schleswig-Holstein, that of all the buildings struck, 9 per cent. of those having hard roofs and 68 per cent. of those having soft roofs were set on fire. The nature of the building and the purpose for which it is used will, as we readily see also in our own statistics, influence the liability to stroke and fire.

State.	Barns.		Dwellings.	
	1891.	1892.	1891.	1892.
Connecticut	9	**23**	6	**16**
Delaware	4	5	..	..
Illinois	17	7	7	**12**
Indiana	31	38	7	9
Iowa	19	6	..	..
Kansas	1	2	..	..
Kentucky	3	4	..	..
Maine	21	23	7	**16**
Maryland	12	8	..	**6**
Massachusetts	12	15	8	**12**
Michigan	26	**70**	..	**13**
Minnesota	7	5	4	6
Mississipoi	1	..	..	..
Missouri	2	1	2	3
Nebraska	1	..	..	..
North Carolina	2	3	..	2
New Hampshire	2	2	..	..
New Jersey	14	**30**	3	7
New York	30	**117**	5	**23**
Ohio	26	26	6	4
Oregon	2	..	..	..
Pennsylvania	29	**73**	3	**27**
Rhode Island	1	4	..	2
South Carolina	3	..	..	..
South Dakota	3	3	..	..
Texas	4	7	..	..
Virginia	4	..	..	2
Wisconsin	6	11	2	3

One interesting point which appears to be shown by statistical studies of lightning stroke is the decreased liability to accident in thickly settled communities.

It may be said in general, that the risk in the country is five times greater than in the city. For ordinary dwelling houses, not unduly exposed in city blocks, lightning rods are hardly necessary, a very considerable protection being afforded by the tin roofing, numerous cornices, gutters, etc. The geological as well as the topographical conditions may have some influence upon the frequency of lightning stroke in a chalk formation, 2 will represent the liability to marl, 7 for clay, 9 for sand, and 22 for loam.

With regard to trees, the oak is more frequently, and the beech less frequently, struck. The values are something like, if 1 represents the frequency for the beech tree, 15 for pines, other trees generally averaged at 40, and 54 for oaks. The trees struck are most generally those standing in the clear or on the edge of forests and in height averaging from 16 to 20 meters (52 to 66 feet). The trunk appears to be struck about three times as often as the boughs, and generally the stroke seems to travel to the ground. Only in three out of one hundred cases did it jump to other trees.

Mr. Symons,* in his paper on thunder storms, instances 16 trees struck. About one-third of these were elms, with the oak, ash, poplar, in order following, and one case each of crab lime and willow.

It is interesting to recall at this point the record made by Hugh Maxwell as early as 1787, that the elm, chestnut, oak, and pine were often struck, the ash rarely, and the beech, birch, and maple never. This last, however, is not true. Indeed, it is not altogether plain just why some trees escape while others suffer. Captain Maclear,† discussing the action of lightning

* Circular of Information, United States Weather Bureau, abstract.

* Page vi. "Lightning Conductors and Lightning Guards."

* Beitrage zur Statistik der Blitzschlage in Deutschland; von Dr. Hellman, Berlin, 1886.

* Also, Appendix E. "Report of Lightning Rod Conference."

† "Quart. Jour. Met. Soc.," 1890, p. 229.

during a thunderstorm on June 6 and 7, 1889, found a great number of trees struck within a radius of four miles, and set to work to discover, if possible, the cause of the selection of these particular trees. "It is not easy to see," concludes Maclear, "the cause of selection, for these trees were not the most prominent, nor were they on the highest ground in the vicinity, the only feature the group possessed in common being that they were all either near ditches which were full of running water or else near temporary courses taken by the deluge of water from the higher to the lower ground."

Some statistics of the damage done by lightning stroke in Belgium,* in 1889, may be appropriately inserted here. Of 324 lightning flashes, 2 struck lightning rods; 123 struck buildings, setting 36 on fire; 16 struck persons; 96, trees; 81, telegraph and telephone lines; and others miscellaneous. In other statistics we find that of 18 deaths due to lightning, 1 occurred within a dwelling, 11 out of doors, and 6 under trees Contrasted with the cases of death resulting from lightning stroke, let us look at 43 cases of persons struck, with results not necessarily fatal, and we find that 30 of these were indoors, 23 out of doors, including 4 under trees. No records sufficiently extended and authentic are available to ascertain what proportion of persons struck by lightning are killed outright. I know of but one record, and in that of 212 persons struck 74 were killed. This question, which is of the greatest interest, is referred to again under the last of the rules given further on for the protection of life.

One of the peculiar and most common characteristics of the action of lightning is the tearing off or throwing effect. This, as we shall see further on, is just what might be expected from discharges of great frequency of alternation. Some interesting statistics are given by Parnell† on the mechanical tearing off and disruptive effects of lightning and distinguished even from the heat effects. He records 1,147 cases. Of these 224 do not permit a determination of the character of the work done by the stroke of the remaining 923.

	Mechanical work.	Heat.
Persons and animals	52	79
Cloths, carpets, canvas, woolen, linen, and cotton goods	88	79
Masonry of all kinds	416	2
Glass, china, earthenware	82	5
Metal	206	173
Wood	254	98
Trees	63	4
Ground	60	..
Thatch, straw, etc	..	11
Gunpowder	..	15
Gas	..	19
Total	1,221	485

Colonel Parnell gives, furthermore, the details in 278 cases to show the existence of an upward direction in the force of the stroke.

This, and the statement that "probably few persons are aware that lightning strokes are more apt to bend or break metal than to fuse it," are, in the light of the investigations of the past three years into the character of the lightning flash, easily comprehensible. A lightning flash being a break in the air (i. e., the dielectric), when the electrical strain exceeds a certain value, determined by several variables, the strongest mechanical effect may be found in any direction, upward or downward. Speaking popularly, flashes may go from cloud to earth, earth to cloud, or from cloud to cloud to earth.

MOISSAN'S CONTINUOUS ELECTRIC FURNACE.

MUCH space is given in the Comptes Rendus to a description of a continuous electric furnace in which materials may be melted out of contact with the carbon vapor of the arc. The body of the furnace is constructed of bricks of lime surrounding a central cavity, the sides of this cavity being lined with alternate plates of carbon and magnesia, the latter being next the lime, as, if the carbon plates were in contact with the lime, combination would occur at the high temperatures reached, liquid calcium carbonate being formed. The magnesia plates are irreducible by carbon, and therefore can only waste away by direct volatilization. The cavity is closed with simple plates, above which is placed a block of lime. The arc carbons pass through opposite walls of the furnace and the arc is struck between them in the center of the cavity; below the arc and above the bottom a tube of pure carbon, one or two centimeters in diameter, passes through the furnace from side to side and is inclined at an angle of thirty degrees to the horizontal. The ores to be fused are placed in this tube, and the arc struck, the metal as reduced flowing down to the lower end of the tube, where it can be collected. Using a current of six hundred amperes at sixty volts, an ingot of chromium of two kilogrammes weight has been produced; the fused metal was cast in moulds of sesquioxide of chromium, to which it gave up any carbon it originally contained. The heated part of the carbon tube is transformed into graphite.

TELEGRAPHIC COMMUNICATION BY INDUCTION BY MEANS OF COILS.

IN a paper recently read before the Royal Society of Edinburgh, by Mr. C. A. Stevenson, the results are detailed of some experiments with the view of establishing communication between North Unst lighthouse, situated on Muckle Flugga, and the mainland, and thence to the lighthouse station at Burra Fiord, a distance of two miles. A number of experiments were made in the laboratory to discover the laws of the action of coils on each other, with a view of calculating the number of wires, the diameter of coils, the number of amperes, and the resistance of the coils that would be necessary to communicate with Muckle Flugga, and after a careful investigation, it was evident that the gap of 800 yards could, with certainty, by bridged by a current of one ampere with coils of nine turns of No. 8 iron wire in each coil, the coils being 200 yards in diameter. It was found that 100 dry cells, of 1·2 ohms resistance each and 1·4 volts, gave good results, the observations being read with great ease in the secondary by means of two telephones. The cells were reduced in number down to 15, and messages could still easily be sent, the resistance of the primary being 24 ohms and the secondary 200 ohms. The hearing distance is said by Mr. Stevenson to be proportional to the square root of the diameter of one of the coils, or directly as the diameter of the two coils, so that, with any given number of amperes and number of turns, to hear double the distance requires double the diameter of coils, or double the number of turns, and so on. But this is within certain limits, for when the coils are close to one another the law does not hold. With regard to the question whether or not the parallel wire system is actuated by induction or conduction, it will, Mr. Stevenson says, depend how the ends are earthed, or, in short, what is the distance bridged in comparison to the breadth of base which predominates. Where the wires are long in comparison with the distance bridged, conduction will be the main working factor, but when the base is small and the distance bridged is large in comparison, induction will be the main factor, and the number of turns then increases the effect.

PHOTOGRAPHY AS APPLIED TO PROCESS WORK.*

By LESLIE E. CLIFT.

I PROPOSE to pass in review the various photo processes that a block must go through before it is ready for the hands of the printer. By process work I refer to illustration blocks used in the ordinary printing press. These blocks are of two kinds, known as "line" and "half tone." A line block is one in which the whole effect of the picture is obtained by lines drawn by the artist before the photographer commences his work at all, or by tints which are laid on the plate by transferring from paper, and which have nothing to do with photography. On the other hand, half tone blocks are such as are made from photos, wash drawings, oil paintings, and other copies of this description, which contain a scale of half tones which must be translated into a grain or stipple for the printer, there being of course no half tone in his ink. As the photographic treatment is somewhat different, we will take the simple line block first.

THE BEST COPY FOR LINE ENGRAVING.

Now, first of all, as to the copy that a line block should be made from. In order to obtain the best results, a drawing should be prepared specially. Although, of course, line blocks can be made from all sorts of copies, including old illustrations in books, when drawings are made specially, there are a few things which require attention. What the reduction should be in photographing is a question of some importance. A very large reduction is recommended by some artists, but I do not think it necessary, especially when it is remembered that the cost of the drawing is correspondingly increased. The most suitable reduction for commercial work is from a quarter to a half, i. e., a block to be three inches wide should be reduced from a copy, say, four or six inches wide. Although frequently I have to reproduce line copies to same size or even to enlarge them, it certainly is desirable that the copy should be larger than the block required, to allow for reduction. The best copies are those having absolutely black lines on white ground, such as would be obtained by drawing on Bristol board, because you then get a very fine surface, which reflects an intense light. As to the apparatus required, little need be said by me except that the copying easel should have two movements, and be easily kept vertical and square with the camera, which, with the easel, is generally made to run on rails. The camera should be as simple and as rigid as possible. It should have a very long extension, and be without any fancy movements, swing back or fronts, and everything easily capable of being clamped square.

PREVENTION OF VIBRATION.

The next point is that one is generally troubled with vibration, and to surmount that difficulty the simplest procedure is to swing the whole thing up, especially for half tone work. In London it is absolutely necessary to support your whole tackle somehow clear of the floor to do work of this sort. I built my easel, in one instance, on a composite girder with a lot of timber in it, and steel plates. The camera ran on rails, and the whole was supported on pieces of India rubber four inches thick, which were flattened down to two inches. Of course that is very rigid. The dark slide should be furnished with carriers or bars, and it is desirable to have a roller front shutter. It is needless to say that it must be well shellacked inside, and silver corners to plate holders are indispensable.

DRY PLATES VERSUS WET COLLODION.

We now come to the first great question the process operator has to ask himself, namely, what process shall he use for making his negatives in copying, wet or dry? I think I can say at once that this has been settled by all the commercial houses in favor of the wet process. I frequently notice in photographic papers articles with such headings as "Dry Plates for Process Work." It sounds very pretty, but here let me say that most of the articles seen in photographic papers on photomechanical subjects must be taken with very great reserve. I think people who are in the process business will be almost unanimous about that. There is a great difference between working a process as a scientific process and as a manufacture process, and the latter is pretty well what the process work of to-day has come down to. It is not what can be done on dry plates, but what can be done at a price, and a very close price it often is too. In my opinion, however, even from the point of view of quality, no dry plate can possibly compete with the wet collodion for line copying. What we want in our negative is, of course, the exact reverse of our copy; that is to say, a negative with absolutely clear lines and absolutely black ground. This is very much more difficult to achieve in practice on a dry plate than would at first be thought to be the case. A sufficient density may be easily obtained with a good light and full exposure, but it is not so easy to keep the lines clear while getting a sufficient density, and clearness of the lines is certainly of the first importance. The real test is to lay the negative face down on a piece of white paper in a good strong light, when the picture should show perfect in white lines on a black ground. I have brought some negatives with me, in order to illustrate what I mean. These are all wet collodion, and I have never seen a dry plate negative which shows the picture so perfect when you place it on white paper. You need not always get density if you can obtain clearness, but this latter you must get. Many people have tried to convince me that dry plates are the thing for copying. I started with them, but I have never seen a negative on a dry plate yet that would really stand the test to which I have just referred by the side of a wet plate negative. In looking through the plate, that is to say, viewing by transmitted light, the lines often look a good deal clearer than they actually are, and intensification, which nearly always has to be resorted to in this work, will almost invariably clog the lines on dry plates, or at any rate stain them. Then again, when you get bad copies on dirty, old, or yellow paper, with many lines faint and brown or so fine as to be hardly perceptible, the difficulties are increased a hundredfold. If you give an under-exposure to save these faint lines, all the work will thicken up, and the result will be a very rough block. To get fineness, you must give a full exposure. If you give a proper exposure to get density and sharpness of outline, all your fine work will go. Passable results from such copies are much more easily accomplished on a wet collodion plate, for by the comparatively easy process of wet plate intensification, we can with a short exposure, which will save the faint and fine lines, get the density up, even from a bad copy to almost anything we like. I am afraid that the gentlemen who write and recommend gelatine dry plates for copying for process work must either be interested in the manufacture and sale of dry plates or else are semiscientific gentlemen who can see no reason why any sort of negative should not be got on a dry plate, for they certainly can never have had any experience of working the process commercially, or they would never write as they do.

COMPARISON OF COST.

Another and, at present in itself, a fatal objection to the use of dry plates is that of expense, especially in the larger sizes. The prices are as follows; whole plates, 5s. 6d. to 6s. 6d. per dozen; 10 by 8, 9s. 6d. to 10s.; 12 by 10, 13s. to 16s.; 15 by 12, 23s. to 28s.; 18 by 14, 31s. 6d. to 48s.; 20 by 16, 54s.; 24 by 20, 80s. Now, what is the expense of a 15 by 12 wet plate? I suppose the silver in it would be well covered by 1½d. The chief expense of dry plates after all is not the cost of the silver and the gelatine and the coating, but the cost of the glass. In a wet plate process this is reduced to a minimum, as the glass is used over and over again, the negatives being taken on a good quality of patent plate, about $\frac{1}{8}$ inch thick in the smaller sizes, $\frac{1}{4}$ inch thick in the larger sizes. The quality of the glass is of very great importance, first for flatness in the camera when standing in the dark slide; and, secondly, to prevent breakage of the negatives when in the pressure printing frames. The quality of the glass on which the modern dry plate is coated is generally very bad indeed, being nothing more or less than common sheet. It is usually full of pits, and frequently has little bits of grit or cinder on the surface, which will most certainly break the negative when it is screwed up tight under the metal in the pressure printing frames. I have found this happen over and over again with dry plate negatives; whereas if the glass for the wet plate negative is carefully chosen in the first instance, such a mishap is of the rarest occurrence. You may break your front glass and printing frame before you break your negative. The collodion film is easily cleaned off by simply immersing the plates in dilute nitric acid, and the glass, after the usual wet plate cleaning, is ready for another negative the next day. With regard to results, I think I have tried nearly every photomechanical dry plate which has been put upon the market, with pretty nearly every sort of developer, including pyro-ammonia, pyro-soda, hydroquinone, eikonogen in various formulæ, rodinal, amidol, etc. I do not think it is a matter of developer, but that the fault lies in the plate itself, that is to say, in the vehicle gelatine. If we could have a dry plate made with a coating of hard gelatine of close texture, not much thicker than the collodion, and of about the same speed, we should be able to develop our negatives about equal to the collodion, in all but the density. But what advantage should we have gained then? I venture to think none at all. It seems to me that all the people who write in the papers booming dry plates for process work make and then magnify all the difficulties for the wet process that they can. They talk about baths going wrong, and streaks and comets, and dirt and mess, as if the process could not possibly be worked without these. As a matter of fact, the exact contrary is the case, as all real old wet plate workers well know.

SUCCESS WITH THE WET PROCESS.

Given average intelligence, ordinary care, and above all, cleanliness, and the wet plate process is quite as simple and easy to work as the dry, and for time of production and cost of working will beat it out and cut. In over four years' constant working I have not had a silver bath go wrong once, except for old age, and being saturated with ether and iodide, the remedies for which are obvious and simple; or else from putting it into vulcanite or gutta percha bath holders, which in my experience will always turn a bath wrong and make it give foggy negatives, ending with your getting no image whatever. As I have said, the great secret of success in the collodion process is cleanliness, cleanliness everywhere, and cleanliness all through. If you put a lot of foreign matter into your bath, it will naturally go wrong.

CLEANING THE PLATE.

Plates must be carefully cleaned before coating, and

* Evrard and Lambotte. Ciel et Terre, 1891: No. 7.

† "Quart. Jour. Med. Soc.," vol. vi., 1885. See also Col. Parnell's book.

* Extract from a paper read at the Camera Club conference, 1894.—Wilson's Photographic Magazine.

must not only be cleaned back and front, but on the edges too, as a great deal of foreign matter can get into the bath on the edges of a glass plate. This subject of cleaning plates is so important, although so old, that I propose to describe the procedure to you. Many people are in favor of cleaning plates on boards, but to my mind that is a great mistake. The plates should be held in a wooden plate holder which must be heavy and strong, and the plate cleaning solution applied from a bottle with a slit cut in the cork so that the contents can only dribble out. The plates should be gone over four times—first, with wet rag with cleaning solution; secondly, with dry rag after the moisture has almost dried off the plate; then with first leather; and, lastly, with the second or finishing leather. These leathers should be kept carefully in a box by themselves, and used for nothing else. You can easily tell if a plate is clean, by simply breathing on it. They are best cleaned in batches, instead of singly as they are wanted, as much time is thereby saved. The plates must next be edged with a coating of India rubber solution, about an eighth of an inch wide, so as to keep the collodion from slipping off. Masticated rubber dissolved in benzole is about the best thing to use for the edging, which should be allowed to dry before coating is commenced. Just before coating dust plate with a camel's hair brush, but do not excite it so as to get a lot of electricity in it.

THE COLLODION.

The collodion I have used all through for this work is Mawson's standard negative, or, much better still, photo-litho collodion, as it is made and oxidized especially for giving density. In America most operators make their own collodion, but while we can obtain such a good article in this country I do not think people here will trouble to make it for themselves. Collodion should not be too old; that everybody knows. (Col. Gale: What age?) You never really know how old it is when you buy it, but I should not purchase more collodion than would last me six months, or iodize more than I should use in a month.

SENSITIZING THE PLATE.

When the collodion, after being applied to the plate, has set, you should lower into the silver bath without stopping. (Col. Gale: Is the coating always done by hand?) Yes. In large sizes we sensitize, as I suppose every one does, in a wave bath. The bath is a very big thing fitted on a carriage. The solution passes over the plate in an even wave without stopping at all, and it is the best way for coating plates over 20 by 16. To sensitize will take from two to three minutes with a new bath, and from seven to eight minutes with an old one. When it requires the latter, time is wasted, and it is better to take the bath out and put another one in. When a plate is properly sensitized, it should look a uniform ivory white. A great point is to well drain all the solution off, and put the plate on to slips of blotting paper, so that no solution runs up the plate again, otherwise you will get no good results. A piece of wet brown paper is a very good thing to put on the dark side. It acts as a sort of backing, and prevents the bright reflection from the spring of the back shutter, which would sometimes spoil a half tone picture. The bath is composed of silver nitrate and distilled water, and must be distinctly acid for line work, and slightly acid for half-tone negatives. Its strength should be 30 to 40 grains to the ounce for line work, and 40 to 50 grains for half tone, and you should not go much below 30 grains for the one, or 40 grains for the other. I make 240 to 250 ounces of bath at a time.

THE EXPOSURE AND REVERSAL.

The exposure is practically always with electric light, as daylight is scarcely any good at all in London for commercial work. You require two lamps, those I use being two arcs each 15 amperes at 60 volts and fitted with reflectors. These lamps are sold as 3,000 candle power, but of course they are nothing like that. You must take line negatives with a small stop. (Mr. Kapteyn: What stop?) I cannot say offhand exactly what stop, as it depends upon the copy, but it must be a small one. You must take a reverse negative, really a left-handed one, which can be done in three ways—by taking a negative through a mirror, by a right-angle prism, or by stripping your film. Stripping is largely resorted to in America, but I do not like it at all. It is not much trouble, but I do not think it gives quite such good results. Those which I hold in my hand are ordinary collodion negatives, treated with very thin India rubber solution. You may crumple them up, but they will come out again all right, and they are very strong. The most practical way of taking such a negative as we are speaking of is by a prism or a mirror. I like the prism for the work, because as soon as you get it properly mounted all your trouble is at an end. On the other hand, the mirror will be a constant source of trouble. Of course, the mirrors for this purpose are very carefully made, having patent plate optically worked and silvered on the surface, but they are always tarnishing and requiring to be cleaned. I recommend strongly the prisms for small sizes, but for the large sizes you must have mirrors.

DEVELOPMENT.

With regard to the developer, it is an old iron one, and consists of 2½ oz. iron sulphate, 1¼ oz. ammonia sulphate of iron, 9 oz. glacial acetic acid, and 60 oz. distilled water, and for using it you must add equal quantities of water and developer. Also add a certain proportion of spirits of wine [wood alcohol]—1 to 5 oz., according to the age of the bath. The spirits of wine does not play any part in the developer, but is added to make it flow evenly over the film. The quantity must be increased as the bath gets older. To 60 oz. of bath I should not add to start with more than 1 oz., but as the bath gets older and tends to get greasy you will have to increase it to 5 or 6 oz. This developer, of course, is very different from the dry plate developer. The development takes place with the plate in hand, and you should develop with as little solution as possible. Keep the developer on the plate, or the image will be thin, as free silver nitrate of film is required to mix with developer to give density; but stop directly the detail is out in order to keep your lines clear. Then just rinse under the tap—and the best taps for this purpose are the swing arm rose taps—and fix by floating plate with cyanide of potassium, sat. sol. one part, water two parts; wash for a minute or two, and the plate is ready for intensification. This should be carefully proceeded with and not overdone.

INTENSIFICATION.

Several intensifiers can be used, but two are used principally. The first consists of 1 oz. chloride of ammonia, 40 oz. water, and 1 oz. bichloride of mercury. Ammonia solution 1 to 6 or 8. A better intensifier is ½ oz. ferricyanide potassium, ½ oz. nitrate of lead, and 12½ oz. water, filtered before being used. When it is thoroughly bleached, which may be known by its turning a bright lemon yellow color—care being taken that intensification is not carried too far, so as to clog any fine work in the picture—it must be well washed until all the yellow color is got rid of and the film is quite white. This will take from three to about ten minutes, according to the amount of running water used, and it is best done quickly. The plate must then be treated with a couple of washes of very weak nitric acid (about 2 drachms to 20 oz.) flowed rapidly over, and not allowed to stop on the film. This will clear any light scum or deposit that there may be on the surface of film, and keep the lines quite clear. Then just rinse under the tap again, and blacken in solution of ammonium sulphide, 1 to 4; wash quickly under tap, and flood again with the weak solution of nitric acid, rinse off and the negative is finished.

VARNISHING.

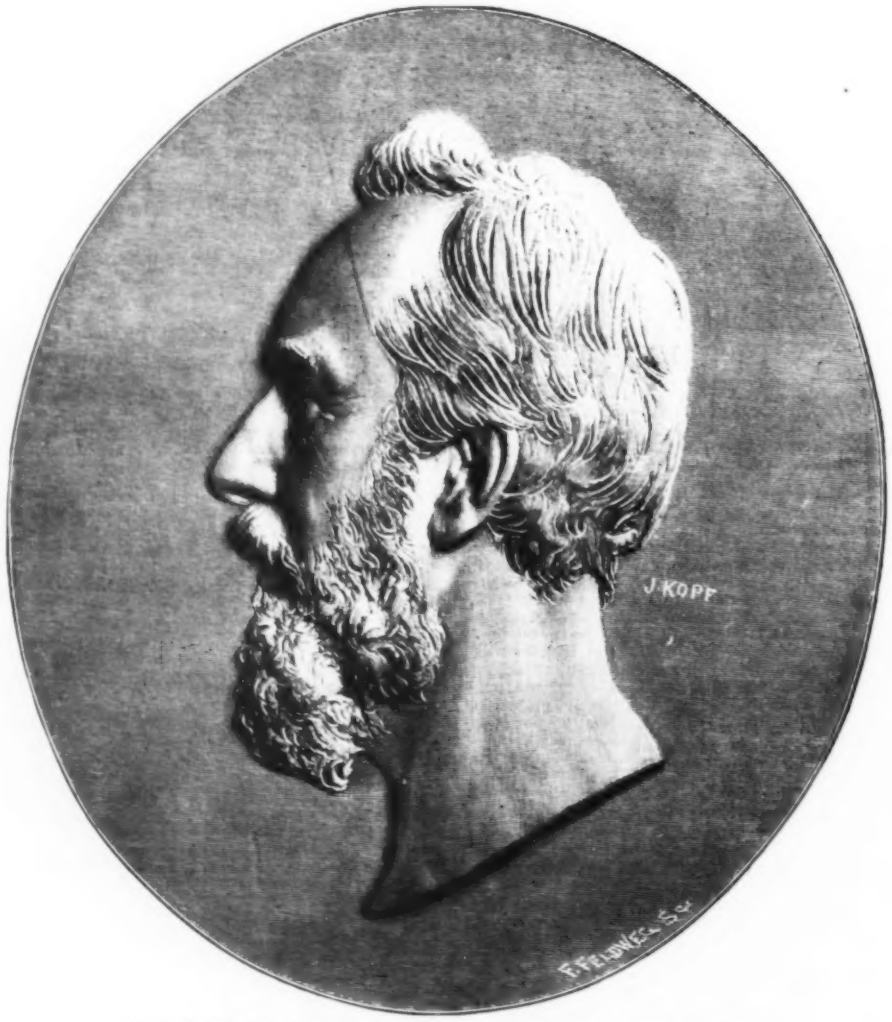
With regard to varnishing, I much prefer none at all, and very seldom use any in ordinary work; but if several prints are likely to be required from the same negative, a protective coating must be applied. Water varnish is recommended by some, but is of very little use. The better way is to coat the plate with a thin film of rubber dissolved in benzole, and then a coating of plain collodion on the top of that. The negative will dry in about 30 minutes, or it may be heated over gas as hot as the plate can be held in the hand, and in this way it will dry in two or three minutes. Defects are best worked out, or additions made, on the metal plate, and not on the negative.

PRINTING ON ZINC OR COPPER.

Now I come to the printing process. Of course, we have to print on metal—zinc for line work, and zinc or copper for half tone work. Most work is done on zinc, on account of the cost of copper being seven or eight times the cost of zinc for the area used. There are many methods of printing. The oldest is the bichromated albumen; then there is the bichromated gelatine process, a pretty process for copper work, either in the form of coating on the metal (copper) or carbon transfer; the bitumen process, which is much used in this country; and, lastly, glue sensitized with ammonium bichromate. The albumen process is nearly always used for line work, on account of its speed, whereas the great drawback of the bitumen process is its slowness. The gelatine process is good for copper, and was very largely used until the fish-glue process was made known. The copper is coated with the bichromated gelatine emulsion, on a horizontal whirling machine, and developed with hot water. The action of light makes bichromated gelatine or albumen or glue insoluble in water. The thickness of zinc plates is 14 wire gauge. Of course the zinc must be quite flat for half tone work, as you must have contact between the metal and the negative. Pumice stone should be used for cleaning purposes. It then has to have a grain given to it, which is done in a bath of very weak nitric acid. The graining must not be carried too far, or the albumen will get too much of a hold and not come away in development. You should grain until you get just a uniform gray color, and then clean the surface of the plate with cotton wool, and coat by flowing twice with albumen solution. This is made with albumen of two eggs, 12 oz. of water, and 2 oz. sat. solution of bichromated potash. The eggs must be well beaten up to a froth and allowed to settle, and then the albumen well mixed with the water, and the bichromate added, and shaken up. After this add one or two drops of strong ammonia, until the whole turns a very pale yellow. Then filter through a pledget of cotton wool, and the solution is ready for coating. The coating is nearly always done face downward in a whirler. Whirl for about 30 seconds, and dry by a gentle heat over a gas stove. The next thing is to put the plates in pressure frames with strong screws, and plate glass fronts ⅝ inch thick for whole plate, ⅞ in. thick for 18 by 16 plate, and inch thick for 24 by 20 plate, and screw up until you can see Newton's rings form between the two glasses. In summer the printing can be done by daylight, but at other times of the year the electric light is much to be preferred. The arc lamps I used are 45 amperes, and I place the frames at a distance of about 22 inches from the lamp for 20 minutes sometimes a little longer, and sometimes not quite so long. The time can easily be determined by a simple silver-paper actinometer with graduated tints.

ROLLING UP.

The plate has then to be rolled up with stiff litho-graphic transfer ink, thinned with turps only. Get the ink very thin and even, and let the turps evaporate. The plate is developed in cold water, with a piece of cotton wool. You must rub pretty hard, and so it is necessary to have an ink that will not smear. If you cannot rub hard at this stage without the ink smearing, you may know that your coating is not on hard enough to stand the etching. If, on the other hand, you are able to rub hard when developing, and have heated it well to make sure of coagulating the albumen, your etcher will have no excuse for not giving you a good block. At this point the photographic operation of the block finishes, and what follows has nothing whatever to do with photography.



ERNST HAECKEL.—FROM A MARBLE RELIEF BY J. KOPF, OF ROME.

ERNST HAECKEL.

THE accompanying engraving (for which we are indebted to the Illustrirte Zeitung) represents a marble relief of the celebrated savant, Ernst Haeckel, by J. Kopf, of Rome. This relief is considered such an excellent likeness that when it was decided to celebrate Haeckel's sixtieth birthday—Feb. 16, 1894—by the unveiling of a bust of the zoologist, in the Zoological Institute, Kopf was selected as the proper person to model it. The first plan was to invite only a small circle of Haeckel's friends and pupils to participate in this festival, but the circle broadened, and soon an interest was manifested by people of all classes, including naturalists, physicians, philosophers, philologists, theologians, lawyers, poets, artists, professors and students in all parts of the world, and in a short time

more money was subscribed than was required for the festival.

It is not strange that Haeckel's work should be thus appreciated, for he was not only one of the first to recognize the importance of Darwin's writings, but after Darwin's death he carried on the work that he had begun, making the University of Jena the center of this line of thought.

ARTIFICIAL FERTILIZERS.

LIEBIG said: "We cannot suppose that a plant can attain maturity even in the richest mould without the presence of matter containing nitrogen, since we know that nitrogen exists in every part of the plant. . . . We have not the slightest reason for believing that the nitrogen of the atmosphere takes part in the processes of assimilation of plants. But there are numerous facts showing that the formation of substances containing nitrogen in plants takes place in proportion to the quantity of ammonia, derived from animal matter, which is conveyed to their roots." Although plants are constantly bathed in air, which consists mainly of nitrogen, and although nitrogen is an essential constituent of plants, yet Liebig believed that all plants would starve unless supplied with nitrogen in the form of ammonia.

De Saussure kept plants in a glass globe containing pure air, free from ammonia. He said: "I continued the experiments a long time, but I never could detect a diminution of the air in the globe. Plants do not absorb nitrogen from the air, and these experiments are confirmed by those of Woodhouse and Sennebier. It is certain that plants derive nitrogen only from ammonia."

Boussingault concluded that leguminous plants, pease, beans, clover, etc., possess the power of appropriating, as food, nitrogen from the air, while cereals and all other cultivated plants do not possess this power.

Professor Hellriegel and his associates discovered that there is a relation between certain knotty protuberances, or root tubercles, which abound upon the roots of leguminous plants, and the acquisition of nitrogen from the air. It was found that leguminous plants whose roots are free from tubercles do not gain nitrogen; that leguminous plants which have root tubercles gain nitrogen, and that leguminous plants which are free from root tubercles gain tubercles and also nitrogen by inoculation with a needle from the punctured root of a plant of the same kind which possesses root tubercles, or by simply sprinkling soil, or infusion of soil, from plants having root tubercles upon the roots of the plants which possess no root tubercles. The inference from these facts is that the acquisition of nitrogen from the air by leguminous plants, which causes them to improve soil instead of exhausting it, is due to micro-organisms, bacteria, or fungoid growths, and it suggests the possibility that, under conditions yet to be learned, other plants may also feed upon the nitrogen of the air.

The hydrogen which is taken up by plants appears to be obtained by the decomposition of water, the oxygen being given off. The carbon, which is the principal element in plants, appears to be derived entirely from the small percentage of carbonic acid gas which is always present in the air. If it is possible also to derive the nitrogen, which is a necessary element in plants, from the air, then the matter of fertilizing soil will be limited to supplying the non-volatile or mineral elements required by plants.

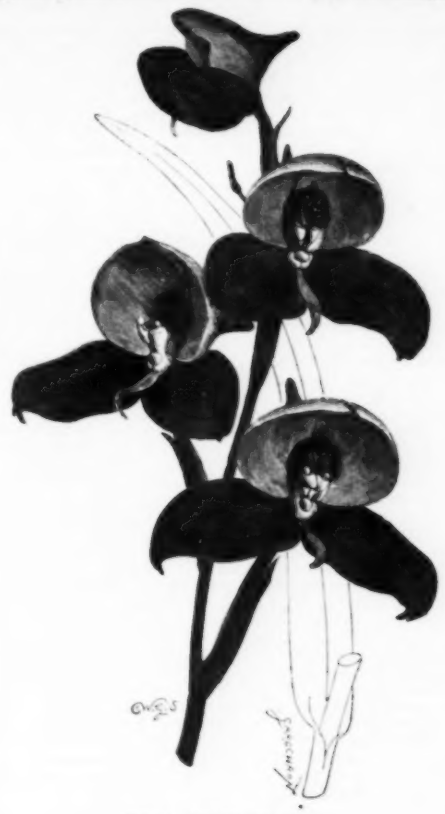
It is said that a process has been recently discovered for utilizing the nitrogen of the air in the production of sulphate of ammonia. It is said the gases or vapors of coal or petroleum are heated to 2,200 deg., the carbon and hydrogen separate, air is introduced, the mixed gases are passed over lime, a cyanide is formed, which is decomposed by steam, and finally sulphate of ammonia is obtained, it is said, at a cost of a cent a pound. We quote this reported process simply for the purpose of showing that the chemistry of a not distant day may be able to extract a fertilizer from the air which will renovate our soils and increase production.

We know that nitrogen is necessary to the full development of our cultivated plants. We know that the atmosphere, four-fifths of which is nitrogen, is an inexhaustible and ever-present source of nitrogen. We know that most plants are unable to feed upon the free nitrogen of the air, and that but one class of plants is able to appropriate it. We know that leguminous plants, beans, pease, clover, etc., which gain nitrogen from the air, renovate and improve our soil instead of impoverishing it. We know that the nitrogen of the air can be combined with hydrogen from organic substances and from ammonia "which is soluble in water and can be conveyed to the roots of plants, which forms soluble compounds with all acids, and is capable of undergoing a multitude of transformations." Sir Humphry Davy conveyed vapor of ammonia through a glass tube into the soil among the roots of grass. He said "a very distinct effect was produced upon the grass; it grew with more luxuriance than the grass in any other place."

Knowing these facts, it seems not incredible that water is a fertilizer, furnishing hydrogen to plants, and that the air is a fertilizer, furnishing carbonic acid and ammonia to plants. When we have learned how to utilize air and water to the best advantage as fertilizers, two blades of grass will grow instead of one. We have not yet learned how to utilize fully the commonest things.—Barbados Taxpayer.

DISA VEITCHII ×.

IN this beautiful plant, obtained by intercrossing D. grandiflora and D. racemosa, Messrs Jas. Veitch & Sons, Royal Exotic Nursery, King's Road, Chelsea, produced the first, and still one of the best, of the new race of garden hybrid Disas, which are destined to become general favorites, as they give a class of terrestrial orchids with most beautiful flowers, which do not require to be grown in an orchid house, as they thrive remarkably well in a shady corner of an ordinary greenhouse or conservatory, if they are carefully tended and kept always moist, rain-water being used for them in preference to water from any other source. The flowers, which last a long time in perfection, are rose-purple, with dark crimson and yellow markings in the center.—The Gardeners' Chronicle.



DISA VEITCHII ×.

RUBUS JAPONICUS TRICOLOR.

THIS is one of Messrs. J. Veitch & Sons' introductions, and was shown by them at the meeting of the Royal Horticultural Society on July 10 last. As seen it was a slender-growing trailer, with stems and leaf petioles of rose color, the leaves showing much white in patches among the green of the rest of the leaf surface, the youngest leaves being pinkish white. It would make a pretty greenhouse climber, or basket plant; or, layered in small pots, a very suitable subject for table decoration.—The Gardeners' Chronicle.

[ASTRONOMY AND ASTRO-PHYSICS.]

THE SEAS OF MARS.*

By WILLIAM H. PICKERING.

THE first observation made upon Mars at the Lowell Observatory with the 18-inch Brashear lens was upon June 1, 1894. Since then observations have been continued upon nearly every night. What appears to me to be the most important conclusion deducible from our work so far is that Mars does not always present the same appearance at the corresponding time upon two successive Arean years. This remark does not apply merely to small details, but to large and prominent features. Moreover, this difference does not seem to be due simply to the fact that one season is a few weeks later than the other, but that the phenomena presented upon the two years are really different.

Thus the central branch of the Y, just north of Noachis, which was so marked a phenomenon in 1892, was not visible to me early in June, as I had expected it to be. It is true that Mr. Lowell thought he saw it faintly marked, but although I looked for it upon the same evening, I could not satisfy myself of its existence. Nevertheless, the definition was such that had it appeared as it did in 1892, it could not have been missed at the first glance. I looked for it again at the following presentation in July just passed, but no trace of it was to be seen. Two drawings made by Professor Campbell upon July 18 and 20, 1892, and published in the last number of the publications of the Astron. Soc. of the Pacific, p. 171, show it very nicely indeed. These may be compared with some reproductions of my own work now originally published in Astronomy and Astro-Physics, 1892, page 608, and now republished in the same number with the drawings of Professor Campbell. After the disappearance of the central branch in the latter part of July, 1892, a portion of it reappeared in August, and remained visible through September. A sketch showing its appearance upon September 4, 1892, has been kindly forwarded to me by Mr. Russell, of the Sydney Observatory, N. S. W. This branch may therefore be said to have been characteristic of the opposition of 1892. This same region was very carefully sketched by Mr. Douglas and myself a number of times between June 30 and July 6, 1894, but not a trace of the central branch could we detect. Upon these dates Mars held the same position in its orbit that it did upon August 12 and 18, 1892. A sketch made by myself August 13, 1892, shows the central branch very clearly. It will be interesting to hear if its appearance has been noted this year by the Australian observers, since in their longitude it would have been visible about the middle of June.

But not only has the central branch of the Y been invisible this year, but the large dark blue patch which it connected with the southern snow cap, and which we call the Northern Sea, has been very much less marked, and much smaller than was the case in 1892.

Again a large black gulf bounding the melting snow upon the north and situated very nearly due south of Syrtis Minor has been a striking feature of our obser-

* Communicated by the author.

RUBUS JAPONICUS TRICOLOR—VARIEGATION PINK, WHITE, AND GREEN.

vations this year. This gulf was only observed once in 1892, upon July 27, and it was then by no means conspicuous. If these very dark regions are, as we suppose them to be, water, it would then seem that the water which did not reach the northern regions this year has appeared as an excess in the south.

Upon testing this black region upon June 4, with an Arago polariscope made for me by Mr. Brashear, it was found to show clear traces of polarization, as did the canal running north from it. This would naturally be the case if it were water, since being situated near the limb, it would reflect to us largely the light of the Arean atmosphere. Upon the rest of the disk of the planet the polarization was not very conspicuous. At the next presentation of this region, upon July 9, the observation was repeated, but to my surprise no trace of the polarization in the dark spot could be detected. A close examination of the region was then made, and its color was found to have entirely changed, whereas upon June 9, Mr. Lowell writes: "Bay a deep blue, looks just as deep water does." It was now found to be of a rich chocolate brown tint, differing entirely in color from the bluish gray regions to the north of it. These gray regions showed no sign of polarization, and as I have before remarked, I see no reason for supposing that their color is due to water. As far as my observations go, it appears to me that the permanent water area upon Mars, if it exists at all, is extremely limited in its dimensions.

The large gray regions were of a brilliant and decided green color in 1890, just before the vernal equinox. In the early part of 1892 also, large green areas were seen upon the planet, but as the season advanced the green regions changed almost entirely to gray. At the present time very little color is visible in the shaded regions. They are subject also to such large variations in area, as the season progresses, that unless we can persuade ourselves that gigantic floods, unaccompanied by clouds, form the normal condition of affairs upon Mars, we seem forced to adopt some other explanation of their existence. The theory that they owe their color to vegetation is perhaps the most plausible one, and some new facts bearing upon this matter have recently come to hand. Upon June 30 a distinct depression in the terminator where it was crossed by the stem of the Y was detected by Mr. Douglass. As the planet rotated, the position of the depression changed, and it was noted that it was not always found in portions of the terminator which were darkest. Since that date similar depressions more or less marked have been detected upon nearly every evening. Upon looking over our observations for 1892, I find under date of September 30, 8 h. 6 m., a drawing showing a flattened terminator, and a statement that "the planet seems somewhat of this shape." Further investigation shows that the long narrow strip known as Ceraunius was lying upon the terminator at about this time. These notches in the terminator can be most readily explained by actual depressions in the surface of the planet, and as Professor Campbell has shown (Pub. Astro. Soc. Pac. 1894, p. 110) a difference of elevation of the surface amounting to two miles ought to be readily visible to us on the earth at certain seasons, provided the elevation or depression involved occurred upon the terminator. It thus appears that we are perhaps on the eve of being able to construct a contour map of the planet. The observations involved are, however, very difficult, and no great accuracy in the results can as yet be expected.

Strictly speaking, the notches in the terminator correspond to variations in the inclination of the surface of the planet, rather than to variations in its level; but if we could determine the inclination and know the distance through which it extended, we should have all the data required for our work.

There is one conclusion, however, to which these observations lead us at once. Since these notches in the terminator do not necessarily occur in the darkest parts of the gray regions, and since different portions of them are notched to different depths when on the terminator, it follows that all portions of the gray regions are not on the same level. In other words, hills and valleys occur in them, and, consequently, the gray regions do not represent the surface of an ocean.

Lowell Observatory, Flagstaff, Arizona, July 13, 1894.

AUSTRALIAN SHEEP AND WOOL.*

By HENRY G. KITTREDGE.

THE foreign wool exhibit at the World's Columbian Exposition had a twofold interest to Americans, because of its great intrinsic merit and of the part it is likely to play in the near future in the manufacturing industry of the country as representative of the wools that will enter our ports in large quantities free of duty. No finer exhibit of foreign wools was ever before seen in the United States. The Argentina wool exhibit was a revelation to our manufacturers for its great excellence, more because of their unfamiliarity with the wools which the exhibit represented than for any particular points of superiority which it possessed over that from Australia. In case of the importation of wool free of duty, the Argentina wools, both the merino and the cross breds, will be more seriously considered for our manufactures than would have been the case had no exhibit of this kind been made.

It is my purpose, however, to confine my remarks to the wool exhibit of New South Wales, with an occasional allusion to that of Victoria, Australia. The colony of New South Wales is the mother colony of the Australian group. Her wool exhibit was under the immediate charge of Alexander Bruce, chief government inspector of stock in the colony, and for the past forty years identified with the pastoral industry of Australia. To him is due the credit of eradicating the scab disease from among the sheep flocks of New South Wales by strictly enforcing the law requiring thorough dipping of sheep at shearing time in prophylactic decoctions.

The New South Wales exhibit contained representative wools from all the sheep districts of the colony except those of Cobar, Ivanhoe, and eleven small districts whose flocks numbered, in 1891, 2,400,000 sheep. Thus less than 4 per cent. of the number of sheep in the colony were unrepresented at the Fair, and this small proportion was confined chiefly to the uninviting region between the Lachlan and Darling Rivers. There are 63 sheep districts in New South Wales, and 20 wool districts, containing altogether, according to the 1891 stock returns, about 62,000,000 sheep. By reference to the map, the various wool districts, or 19 of them, will be seen indicated upon it. It will be observed that the railway intersects most of them. The wool districts, according to their importance in the number of sheep, are as follows:

	Sheep.
Lachlan	5,452,571
Riverina	5,231,146
Upper Murrumbidgee	5,099,381
Upper Darling	4,808,672
Western Darling	4,745,382
Southern Riverina	4,101,115
Castlereagh	4,076,196
Liverpool Plains	4,055,365
Namoi	3,909,830
Western Riverina	3,267,946
Bathurst	2,979,550
Gwydir	2,856,598
New England	2,581,642
Bogan	1,709,055
Monaro	1,439,841
Mudgee	1,181,644
Hunter River	695,152
Goulburn	641,428
Lower Darling	631,176
Total	59,463,990

Over 37 per cent. of this number of sheep are in the districts between the Lachlan and Murray Rivers; over 24 per cent. in the northern districts, from Castlereagh River to the upper tributaries of the Darling River; and nearly 14 per cent. in the Upper and Western Darling districts.

There are about 13,300 sheep owners in New South Wales; 750 of these own over 62 per cent. of the whole number of sheep. The flocks owned by these large proprietors range in size from 20,000 to 500,000 and 600,000 sheep. Seventy-three of these own nearly one-sixth of all the sheep in the colony, distributed among the different wool districts as follows:

Seventeen in the Riverina and Lachlan districts, owning 2,528,704 sheep; 15 in the Upper Darling, Bogan, and Castlereagh districts, owning 2,548,384 sheep; 19 in the Gwydir, Liverpool Plains, and Namoi districts, owning 2,440,785 sheep; 18 in the Western and Lower Darling districts, owning 2,420,398 sheep; and 4 in the district about Cobar and Ivanhoe, owning 454,503 sheep. The great flocks are west of the western slope of the mountain range.

The various breeds of sheep in the colony are the Merino long woolsd sheep, as the Lincoln, Leicester, Downs, and Romney Marsh, and the cross breds, principally the long-wooled breeds with the Merino. Over 97 per cent. of the sheep are Merinos. Over 70 per cent. of the Merino sheep yield combing wool, the remainder yielding clothing wool. Over 17 per cent. of the combing wool sheep produce a superfine grade of wool, and about 46 per cent. a medium grade. Of the long wooled sheep the Lincoln is in the greatest favor, though the Leicester is in no mean repute. It is generally thought among the flock masters of Australia that there is no room for improvement in the quality of the Merino fleece by any further admixture of European or American blood. Some efforts have been made in the direction of building up the avoirdupois of the animal, but they have not proved generally successful, as deterioration in the quality of the wool has followed. Large carcasses for mutton, as experience has demonstrated the world over, are inconsistent with superiority in the fineness of wool.

The geographical position of Australia is a grand one, an ideal one for sheep husbandry, where the climate is neither too hot nor too cold, tempered by the breezes that come over the surrounding sea, and where the air is clear and dry. On the east coast there is a chain of mountains generally known as the Great Dividing Range, extending north and south some 1,500 miles, in many places coming within 30 miles of the ocean, and touching it at Point Danger, between Queensland and New South Wales. Its highest elevation is in the southern part of New South Wales, where Mount Kosciusko rises 7,120 ft. above the sea level, and where snow may be found at all times of the year. The colonies of New South Wales and Victoria occupy the choicest parts of the continent, where the climate is congenial, and where the best lands are to be found for pastoral and agricultural pursuits.

New South Wales is divided into three physical divisions, designated as the coast district, the mountain district, and the western district. The latter two we shall have most to do with in connection with my subject. The coast district is a narrow strip of land from 30 to 150 miles wide, watered by a number of small streams having their sources in the mountains. The home of the mutton breeds of sheep is distinctively to be found here. The mountain district embraces the high lands and elevated plains that extend the whole length of the colony and slope gradually toward the west. This district varies in width from 120 to 200 miles. With the extension of the railway system and the increase in population this district is becoming more agricultural and less pastoral. The soil is rich and highly productive; the herbage is excellent, and were it not for the higher wants of agriculture, the land would be taken up from choice for the pasturage of sheep instead of that further to the west. The western district includes all the area from the elevated plains to the Darling River and beyond. All this region is now given over to grazing purposes, and with a general system of irrigation, as is now in contemplation, it will become equal if not superior to the most beautiful parts of the colony for husbandry of all kinds. As it is, sheep thrive there in a remarkable degree, very largely on account of the dry and healthy character of the climate. All the great rivers of the colony are found in this district. From Bathurst, northward to the 25th degree of latitude, all the western streams are tributary to the Darling River. This river is navigable from Walgett to its junction with the Murray River, 1,758 miles, thence to the sea. At some periods of the year its waters are very low; but four, and oftentimes twelve months' navigation, can be depended on as far as Bourke. This allows the transportation of wool and other things at certain seasons. The Murray River and its tributaries form the most important river system in the colony. The Murray has never been known to be dry, being fed by the heavy rains and snow on the mountains about Mount Kosciusko. This perennial flow in such steady volume cannot be said of any other stream in the colony west of the mountains. It is navigable from Albury to the sea, 1,703 miles. The Murrumbidgee River is navigable up to Gundagai, while the Lachlan is navigable for several hundred miles. The great triangular region in the western district, lying between the Lachlan, Bogan, and Darling Rivers, has no surface streams. It is a comparative desert, yet some of the flocks of sheep in Australia are pastured there, about Cobar and Ivanhoe. The wools of this section were the only ones of New South Wales not represented in the World's Fair exhibit. The country northwest of the Darling River, notwithstanding its undulating formation, has, also, no surface streams of consequence, and the few streams there have their beginning and ending in the sands, excepting at occasional flood times, when one or two of the principal ones empty their waters into the Darling. Were it not for this lack of surface water the western plains of New South Wales would be the finest pastoral country in the world. This objection, however, bids fair to be overcome at no very distant time by the sinking of deep wells, by means of which the underground waters can be brought to the surface in abundance. Experiments have been made in this direction sufficient to establish a reasonable amount of certainty that it is possible to obtain an unfailing supply of water from below the surface.

The region west of the Lachlan and Bogan districts is the salt bush country of New South Wales. It is not regarded with particular favor for the raising of fine wooled sheep, on account of the heat and the vegetation peculiar to a light, sandy soil of saline characteristics. But this region is improving, as the country east of it has improved and is improving, for both pastoral and agricultural purposes. All of this broad expanse of country is for the Merino, not the mutton sheep. While the Merino sheep will not thrive in the coast region because of the climate being too moist, the mutton sheep will not thrive in the interior on account of the climate being too dry. But the mutton breeds are not good for a new country for reasons distinct from climate.

The climate of Australia has had a peculiar influence upon the fleece and fiber of Merino wool, improving it in almost all particulars. The wool has been made softer and more elastic. If there has been any deterioration, it is in the density of the fleece; but this has been made good in a large degree by increased length of staple, so that there has been little or no loss in the weight of the fleece. It is difficult to say in what locality climate has had the most beneficial effect upon the fleece of the Merino. Certain it is that no place has been found superior in this respect to the Mudgee district, where an experience of over sixty years has shown that no better wool has been grown than there. So far as experimental knowledge goes, this district may be considered as possessing all the essential elements for the superior growth of Merino wool. The mean annual temperature of Mudgee is about the same as that about Nice, in Southern France. It is very much like that of the great sheep walks of Spain. The mean maximum temperature in the hottest months is about 86°, and the mean minimum temperature in the coldest months is about 38°, taking the records of 1891 as a standard.

The rainfall for that year was 34 inches, but this was 27 per cent. above the average, the mean annual rainfall being nearer 26 inches. The mean annual rainfall in the Bathurst (24), Upper Murrumbidgee (23), and Liverpool Plains (25) districts is about the same—a few inches less. The mean annual rainfall through the Darling River valley is 12 inches at Wentworth, 13 inches at Wilcannia, 16 inches at Bourke, and 19 inches at Walgett. In the Bogan district the mean annual rainfall is 17 inches, while about Cobar and Ivanhoe it is only 12 inches, but through the Riverina districts it is from 26 to 28 inches.

Ever since 1820 there has been a constant improvement in the breeding and preparation of wool for the market. It was about this time that sheep breeding was commenced in the Mudgee district. In 1860 special attention was directed toward improving the fineness of the wool, owing to the increased demand for it at relatively high prices. This led to the importation of French, German, and American blooded Merinos, of the Rambouillet, Negretti, and Vermont types, respectively. The German and American Merinos were in special favor, chiefly for the density of their fleece. Improvement in the length of staple soon followed, because of the increased demand for it for combing purposes. A change in the style of breeding resulted in more attention being given to purely Australian bred sheep, which were found to possess special qualifications for the growth of long-stapled wool, not observed in those imported from Europe or America.

The French, German and American bloods, however, were conspicuous in the specimens of New South Wales wools at the World's Fair. The Vermont blood was found almost, if not wholly, pure in some of the specimens from the Gwydir, New England, and Riverina districts. It was prominent in crosses with Australian types of wool, known as the Wanganella, Collaroy, and Tasmanian. The German blood was found almost pure in specimens from the Hunter River and Mudgee districts. The Collaroy blood, being the name of a stud flock at Merriwa, is derived from a Rambouillet and Saxon cross, and appeared to be a favorite infusion in many of the specimens from the Upper Darling, Gwydir, Namoi, and Monaro districts, and pure in many of the specimens from the Bathurst, Bogan, Castlereagh, Gwydir, Hunter River, Liverpool Plains, and Mudgee districts. Some of the Collaroy fleeces weighed 18 to 19 pounds. The Colloroy-blooded wool is characterized for luster, evenness, and length of staple. The Collaroy and Brinley Park estates at Merriwa are famous for the high character of their Merino blooded flocks. The Brinley Park wool was represented by two specimens at the World's Fair. The sheep from which this wool was taken are descendants of a few rams and ewes imported into Australia, in 1830, from Silesia. Subsequent importations were made, one being made in 1860 of several rams from the renowned flocks of Prince Lichnowski. Great care has always been practiced in culling and

* A paper read before the Society of Arts, Boston, Mass., January, 1894. From the Technology Quarterly.

selecting. This blooded wool secured high honors at the Philadelphia Exposition of 1876. The Mudgee district type of wool is noted for the comparative density of its fleece. It possesses certain distinctive features that give it a classification of its own, and as such was better represented in the wool exhibits at the World's Fair than that of any other. It appeared pure in specimens from nearly all the districts, or crossed with the Tasmanian and other bloods. Another well-known blood in the Mudgee district, Havilah, was represented in a single specimen—one bale—at the Fair, but it failed to attract particular notice. The sheep from which the wool was taken had been pastured on poor soil, badly infested with grass seed. The blood, however, is in good repute in Australia for producing wool that is lustrous and supple and suitable for worsted and hosiery yarns. The wools of Liverpool Plains are chiefly of the Tasmanian, Mudgee, and Collaroy types. In some of these there are traces of Saxon and French blood that was first imported in 1825, and afterward renewed in by some Negretti blooded sheep from Germany. These wools in time came to be regarded as pure Australian Merino wools, being improved from time to time by infusions of blood from the Mudgee district, as the Collaroy, and from the famous stud flock of the Ercildoune estate, Burrumbeet, Victoria. In regard to the Ercildoune wool it may be well to state that the sheep can trace a pretty direct lineage from the first great importation of Spanish Merino sheep into Germany, in 1785, by the Elector of Saxony.

A portion of the electoral flock was afterward purchased and taken to Tasmania, and from the Tasmanian flock thus established a few sheep were taken, in 1838, to start a flock upon Lake Burrumbeet, near Ballarat, that afterward came to be known as the Ercildoune. This latter flock has undergone much classing and selection, till its wool has attained a standard of quality for fineness, elasticity, softness, and luster that has had no superior. It is highly esteemed for mixing with silk. Some of this wool can be spun into worsted as fine as No. 140. In order to accomplish this the wool would have to be as fine as the finest Silesia and Saxony. This means that one pound of this yarn will extend over 44 miles in length. Victorian wools are in more or less favor with American manufacturers. Take the wool, for instance, grown in the neighborhood of Ballarat, as the Lismore wool, which is prized for its light condition and strength of staple. It commands a high price for worsted and hosiery purposes. This wool will spin into Nos. 60 and 70. Victorian wools are characterized by their bold and lustrous qualities, while the Riverina wools are esteemed for their soft and silky properties, and the South Australian for their length, strength, and metallic brightness, with a tendency toward coarseness.

The wools in the Namoi district, New South Wales, are very much of the Walgett type, as represented in some specimens seen at the World's Fair. These wools are raised with special reference to the country in which they are grown, the fleeces being dense and the tips inclined to fuzziness, preventing the heat and dust from penetrating into the fleeces and thus injuring the wool. These qualities are secured by certain crosses of Victorian, South Australian and Riverina bloods. An objection has been raised concerning these wools on account of their hairy or fuzzy tips producing an excess of noils, yet they are capable of producing good worsted yarns of Nos. 60 to 70. The wools grown in the Upper Darling district, as about Brewarrina, are similar to those about Walgett; that is, the fleeces have more or less fuzzy tips. Yet this style of wool is looked upon as particularly useful, considering the circumstances under which it is grown. The heat and dust to which the sheep are exposed have tendency to produce open, loose, hairy tips. Fineness of fiber is not arrived at, but a fiber of medium quality, of good length, that will spin down to about No. 60. Bogan district wool is not unlike that of the neighboring districts, being of medium grade, spinning into the 50's, and in some instances into the 60's. The fleeces are apt to be light on the tip, and, therefore, noil considerably. The wools of the Western Darling district show more or less poverty in the better characteristics of Australian wool. The summer heat is unpropitious for the growth of heavy fleeces. Every effort is being made to improve the wool by the introduction of blood from the best stud flocks of Victoria and South Australia, particularly the latter. It is doubtful if wools of the first quality are ever raised in this section. A fuzzy tip characterizes the fleece. The Riverina districts produce a variety of grades of wool. Some of the best grown in Australia are produced there. Take, for instance, some of the wool exhibited at the Fair from Wagga Wagga, in which Vermont and Mudgee bloods were prominent. The specimens represented a superior type of combing wool. Some of the most perfect wools in the world are produced in this district, being bright, silky, fine and lustrous. The wools of the Southern Riverina district at the Fair were of a high character. Those from Mulwala, west of Albury, were particularly noticeable. These came from a flock of sheep descended from Mudgee, Ercildoune and Tasmanian blooded stock. Trade objections have been made to some of the wools from this section because of a wasty top, causing a large percentage of noils. Seasons, however, have much to do with these defects.

The heaviest fleeces of Australia come generally from Victoria. They become lighter as one goes toward Queensland. The fleeces are more open and freer from yolk. This applies more particularly to the wool grown in the western districts of New South Wales. The average weight of Australian fleeces from stock sheep may be put at six to seven pounds. A plain, not wrinkled sheep is preferred. The advantage of the infusion of American or Vermont blood is that it imparts a density to the fleece which it is difficult to get from the Tasmanian or Mudgee blood. The objection to it is that it gives to the wool a harsher feeling, and the staple is shorter than what is obtained from the stud flocks of purely Australian blood.

The great superiority of Australian wool is supposed to be due mainly to climatic conditions, but no little credit is also due to the grasses and herbage upon which the sheep feed. The native grasses of Australia are looked upon as superior for pasture to exotic grasses. Experience has inclined opinion that way. They possess greater reproductive powers, and there is very little necessity for reseeding. The most abundant variety of grass is that known as the Kangaroo, which not only supplies the sheep with nutritious food but is capable of resisting heat. It is found over all portions of New South Wales and Victoria, and is perennial. It is pronounced by all as being one of the finest and most useful of grasses for pasturage. It sometimes attains the height of three feet when on rich soil. In the autumn, when its foliage turns brown, its nutritive qualities are said to be at the highest, and when cut as the flower stems appear it makes excellent hay. There are other native grasses of great value, among them the millet, which is found throughout New South Wales and is much liked by all stock, and the small burr grass and the variety known as the Wallaby, both of which are favorites with sheep. There are some troublesome weeds in Australia, as the Bathurst burr—known in the United States as the cockle burr—the trefoil burr, and certain thistles. These are exotic, having been introduced from abroad. In the western parts of New South Wales there are indigenous grasses that are perennial and possess fattening qualities even when dried up. The several varieties of the salt bush, a forage plant, grow there, thriving on the arid plains in most adverse seasons of heat and drought.

It is not to be presumed that the arid regions of Australia will always remain as they are now, of little value even for ordinary pastoral pursuits. The soil is undoubtedly naturally rich, requiring only a proper amount of moisture, properly distributed throughout the season, to become highly productive. To accomplish this most desired end a general system of irrigation is contemplated, especially in New South Wales, involving the sinking of artesian wells and the diversion of watercourses. In Victoria no efforts of any moment have been made to obtain water by means of artesian wells, but ditching has been resorted to, and immense tanks constructed for the conservation of rainfall against times of drought. To allow any material increase in the number of sheep in the interior regions it will become necessary to resort to some expedient of this kind to supply surface water for the vegetation. The sinking of artesian wells in New South Wales first received government attention in 1879, and the first practical effort made in this direction was in 1884, near Bourke, where a flow was obtained of 24,000 gallons a day from a depth of 80 feet. Other wells have since been sunk in different localities, in most cases with satisfactory results, in one instance obtaining a flow of 2,000,000 gallons a day. The government is working upon a system of boring series of artesian wells in two lines, one extending from the mountain range to the western boundary and the other from the Murray River to Queensland. The great river systems of the colony can, and unquestionably will, be utilized for irrigation purposes before many years pass by. It has been carefully estimated that the underground supply of water is all sufficient, and obtainable by means of sunken wells, to convert the arid regions into highly productive ones. Take, for example, the 200,000 square miles area drained by the Darling River. The average rainfall over this is 20 inches per annum, and, even assuming that one-tenth of this finds its way into the Darling and its tributaries, in order to carry off the water the river would have to be 200 feet wide and 100 feet deep all the year round, which was never known to be the case, even in flood times. The water, therefore, must sink into the ground and flow at a lower level. If this lower level can be reached and the water brought to the surface and distributed by economical means, the whole aspect of the interior districts of the colony will be changed and verdure prevail where aridity now exists.

Few sheep are now shepherded in Australia. The paddocking system is almost invariably in vogue. By this system the country is capable of carrying one-third more sheep, the fleeces are better in condition and in all other respects, and the wool longer and stronger. The sheep themselves grow to larger size, live longer, and are freer from foot rot and disease. In addition to all this the expense of watching and caring for the sheep is less, and more time is at the command of the owner to devote to the improvement of his flock. In Victoria all the sheep stations are now inclosed by fences, and most of them are divided into paddocks. It has been found that more sheep can be kept and made to thrive on land under fence than when left open for general pasturage. Fencing has become a matter of preference as well as one of necessity. The question of cost is of secondary importance; in fact, it is fully off-set by the improvement in the health and condition of the sheep and in the less expense and trouble attending their care. The cost of establishing a fenced run or paddock is covered in five years by the saving in the cost of labor alone. At first fences were made of logs and brush, where these were obtainable, but now nothing but wire is employed in their construction, at a cost of from $125 to $150 per mile. The usual height of a fence is 3 feet, with the wire strung at intervals of about 6 inches, on stout posts set 120 feet apart. Between these latter are placed smaller posts or stakes at distances sufficient to keep the wires in place. Some runs have several hundred miles of fences. These large runs are divided into many paddocks or inclosures. An average paddock is of about 800 acres in size. In New South Wales there are about 42,000 runs, of which over four-fifths are inclosed, and seven tenths of these are subdivided into paddocks. The area comprised in these holdings is not far from 190,000,000 acres. This would make the average run of about 4,500 acres. Over 80 per cent. of these holdings are leased from the colonial government. All, or nearly all, of the best sheep country in the Australian colonies is now occupied, and any additional increase in the number of sheep which the country can be made to carry must be effected by improvements in the way of irrigation and the character of the herbage. The management of a station consists usually of a manager, an overseer, a bookkeeper and a certain number of boundary riders and common laborers, according to circumstances. The fencing in of sheep runs and their divisions into paddocks has had much to do toward the extermination of the scab disease among sheep. The last license for scabby sheep in Victoria was issued in October, 1874, and on June 6, 1876, the governor proclaimed the colony clean of the disease.

The extermination was accomplished through the rigid enforcement of the Scab Act of 1870, still in force, which requires certain medicaments to be used in the dipping of sheep, consisting of a mixture of tobacco and sulphur in water or of a mixture of lime and sulphur in water, the mixture in either case to be at a temperature of not less than 100° F. at the time of dipping. Two immersions are required at an interval of not less than seven nor more than fourteen days. The lime and sulphur dip is acknowledged to be effective, but it is regarded by sheep men as too severe, making the skin dry and the wool harsh. A preferable receipt, because of its milder action upon the skin and wool, yet equally efficacious for the eradication of the scab, is the tobacco and sulphur one at a temperature of about 104° F.

The loss of sheep on account of disease due to natural causes is almost as nothing compared with that caused by the multitude of rabbits that infest the land by eating up everything that is green and leaving nothing upon which the sheep can feed. With the exception of drought, there is no impediment to profitable sheep husbandry so damaging as the rabbit pest. Colonial laws have been directed toward its complete elimination at a great cost to those engaged in pastoral pursuit, with the great object of extermination still unaccomplished. The colony of New South Wales alone expended during the eight years ending with 1890 nearly $4,300,000 on account of rabbit destruction, and over 40 per cent. of this was derived from assessments, the balance coming from the general revenue. There are various means resorted to for ridding the country of rabbits, such as trapping, poisoning the food and water, shooting, and hunting with packs of dogs. Some idea may be had of the destruction that has been going on among rabbits by the export statistics of rabbit skins from Victoria. For the ten years ending with 1886 there were exported from that colony nearly 29,000,000 rabbit skins.

The shearing season in Australia depends on the location, beginning about the first of July in Queensland and ending about the first of March in Victoria. Thus there is given fully eight months for shearers to ply their vocation, commencing in the northern parts and completing their season's labor in the southern parts. Four months are allowed for rest and return to the north. Much skill is required in the shearing and handling of sheep, and the compensation is rated accordingly. There is a large class of men who do nothing else but follow this employment, which is now subject to rigid regulations in conformity with an agreement reached in 1891 between representatives of the Pastoralists Federal Council of Australia and representatives of the Amalgamated Shearers' Union of Australia. Both of these associations are strong in number and in their organization, and the 1891 agreement was the result of a number of seasons' dissensions, but more particularly the result of a general strike on the part of the shearers the year before, when in many instances sheep remained unshorn till long after the usual time. The main cause of the strike was the employment of "non-union" shearers; but under the agreement employers are free to employ, and shearers are free to accept employment, whether belonging to shearers' or other unions, or not, without favor, molestation, or intimidation on either side. The meaning of all this is "freedom of contract." In New South Wales the agreement establishes the price of shearing at 20 shillings for every 100 sheep shorn, except rams, for which 40 shillings are paid for every 100 shorn. The employer is bound to keep the shearer fully supplied with sheep unless prevented by weather or by some unforeseen cause, and also to provide him with hut accommodations, cooking and table utensils, wood and water free of charge. Certain requirements are made in shearing. First, the sheep must be carefully taken from the pen to the shearing board and the belly wool removed first, where practicable, and laid aside. In opening the fleece at the neck and belly both blades of the shears of the machine must be kept under the wool and close to the skin, so as to avoid twice cutting, and the shearer is not allowed to run the shears through the fleece so as to break it down the center or the back, or to stand on the fleece. The shearer is prohibited from kicking or ill using any sheep. He is forbidden bringing intoxicating liquor into the station or using profane or obscene language in the shed. Shearers are obliged to provide their own cook, except where cooks work conjointly for shearers and employer, in which case the cook is engaged mutually by the employer and shearers. No shearer can be compelled to work more than forty-eight hours a week.

Shearing by machinery is something of very recent date, long desired by the wool growers of the colonies. Of the sixty-nine applications for patents on sheep-shearing machines, only three or four have been received with favor, and at the Royal Agricultural Show, held at Melbourne in 1891, only three competed for the prize offered—the Wolseley, Burgon and one other. The special merits of the Burgon machine are represented to be overhead safety driving motion, which is self-adjusting in its action, and can be operated separately from others on the same line of shafting, and a flexible steel driving shaft made of hardened steel with universal joints. It requires an engine of four horse power to drive ten to fifteen of these machines. The best-known machine in the colonies is the Wolseley, not dissimilar in essential principles to the one just described, and first brought to public notice in 1887. Since then it is calculated that at least 60,000,000 sheep have been shorn by it. There is a variance in the opinion of sheep men as to the economy and general advantage of machine over hand shearing, though the testimony seems to be generally in favor of the machine.

The chief complaint against it is its vibration and the extra strength required in holding the sheep to the shears. For a flock of 30,000 to 40,000 sheep there are required fourteen shearers, two packers, four sorters, one classer, two pickers-up, one sweeper, three or four general utility men, two cooks, besides an engine driver, water hauler and cutter grinder, in case the labor is done by machinery.

As required by the rules of shearing already referred to, the shearer is required to remove the belly wool, if practicable. This wool is carried by the pickers-up to the bins provided for such wool by the side of those for pieces, broken fleeces, etc. The fleeces go to the sorters, who place them upon tables with wire netting tops, the meshes of which are about 1¼ inches in size. The sorter is an important person, oftentimes one who

has had experience in the sorting room of an English factory, and therefore skilled in the art of quickly judging the different qualities of which the fleece is composed.

The fleece is sorted with the cut side down, the loose locks falling through the meshes of the netting onto the floor. The sorter is under the direction of the classer, who is the one chiefly responsible for the proper separation of the fleece into its several parts, an operation known among wool men as "skirting." After the skirting is all done, the body of the fleece alone is left, and this is the only kind of wool that is sent to the American market. Technically, this is called the fleece, the rest being termed the first pieces, which are taken from the neck and from a portion of the skirts; the second pieces, taken from the upper part of the legs; the third pieces, taken from the cheeks, topknot and lower part of the legs; the stained pieces, taken from the breach; the bellies, taken from the under parts, and the broken pieces, or trimmings, not included in the foregoing. After all these pieces, etc., are removed from the body of the fleece, the latter is folded lengthwise, rolled and either tied with cotton twine or secured by twisting in an end of the fleece. The classer receives the wool in this condition and throws it into its proper bin, from which it is taken and pressed into bales of about 400 pounds in weight. Fleeces, whether merino or crossbred, are classed as first, second and third combing, or as first, second and third clothing, as the case may be. Parts of fleeces have various designations, aside from first, second, third pieces, etc., as "dingy fleeces," "ram's fleeces," "tender fleeces," etc. This matter of sorting and classing wool is carried to an extreme, and, in the opinion of many, to an extent that is uncalled for. The stained bellies and locks from the fleece are generally scoured before being put upon the market. According to the record of one flock of sheep in the Riverina territory, the following proportion of classes and sorts was made: 47 per cent. first combing, 4 per cent. second combing, 2 per cent. clothing, ½ per cent. dingy and black, 19 per cent. broken fleece, 4 per cent. first pieces, 8 per cent. bellies, 8 per cent. stained, and 7¼ per cent. locks. 24 per cent. nearly of this clip of wool was scoured, and only 53 per cent. was marketed in the form of fleeces.

The tendency is toward shearing in the grease, which is almost exclusively due to the price obtained for washed wool not being commensurate with the cost of washing. Over 96 per cent. of the sheep shorn in New South Wales in 1891 were shorn in the grease; in 1880 the proportion did not exceed 70 per cent., 17 per cent. being creek washed. The average weight of fleeces shorn in the grease in 1891 was five pounds nine ounces, packed in bales measuring about five feet in length and two feet two inches in breadth and depth, and weighing about 450 pounds. The bales are afterward subjected to hydraulic pressure, and reduced in size about one-half before exportation.

Wool is transported from the stations to the nearest railway by wagons, drawn either by horses or oxen, twenty of the latter often being yoked to one wagon, upon which is loaded as many as 25 bales of wool, and in exceptional cases as many as fifty bales. The cost of cartage overland is at the rate of $1.25 per 100 pounds per 100 miles. Should the distance exceed 100 miles, a discount of 20 per cent. from this rate is made for the additional number of miles. The railway freight from Hay, for instance, to Sydney, a distance of 454 miles, is about 70 cents per 100 pounds of greasy wool; from Bourke to Sydney, a distance of 503 miles, the freight is about 98 cents per 100 pounds, and from Mudgee to Sydney, a distance of 195 miles, the freight is about 66 cents per 100 pounds. It is a matter of report that "not so very many years have elapsed since the Queensland squatter, after seeing his last wagon load started from his station for the coast, would take a run home to England, returning to the colony in time to meet his wool on its arrival at the port of shipment, so long and tedious was the journey. Drays and impromptu slides had to be made; creeks and rivers to be crossed; droughts killed off the bullocks for want of feed and water; floods converted the banks of rivers etc., into 'tented fields' populated by drivers, whose rations often ran low; bush fires menaced the safety of the men, cattle and freight, besides the occasional attacks by natives; in short, wool, while in transit from the far back stations to the seaport, had an adventurous and risky career. There have been instances of two different years' clips being on the road at the same time."

Freight rate from Sydney to London is from about 75 cents per 100 pounds by sailing vessel to $1.35 to $2 per 100 pounds by steamer.

Nearly all the wool sold in Australia is disposed of by auction to the higest bidder at the principal colonial markets. These sales have grown in popular favor and importance, having amounted to 697,705 bales for the season of 1891-92 for all the colonies. For that season 42 per cent. of all the sales were effected at Melbourne and Geelong, and 40 per cent. at Sydney.

The chief and almost only increase in the world's production of wool is in Australia. For the ten years ending with 1892 the wool production of Cape of Good Hope increased about 36,000,000 pounds, that of the Argentine Republic about 66,000,000 pounds, and that of North America about 13,000,000 pounds—in all about 115,000,000 pounds; while that of Australia increased about 278,000,000 pounds, or over 70 per cent. of the total increase. These figures are based on the imports of wool into Europe and North America, where they are alone manufactured and where they are wholly shipped. Practically the wool production of the world seems to be stationary or on the decline in all-wool producing countries except Australia. Nearly 30 per cent. of all the wool consumed is from the flocks of Australasia, and this proportion is increasing every year.

AN ANTIDOTE FOR AFTER DAMP.

ONE of the most practical and useful papers read at the recent meeting of the British Association was that of Dr. J. S. Haldane on "The Causes and Prevention by Death by Suffocation in Mines."

At the outset of his paper, Dr. Haldane states that, according to his opinion, it is not at all generally realized how large a proportion of the men killed in a colliery explosion die from suffocation, and proceeded to give an account of the various irrespirable gases, or "damps," which are found in mines, and which are the causes of these deaths from suffocation. Fire damp, as is well known, consists of marsh gas usually mixed with a little air, and a little nitrogen and carbon dioxide in excess of that due to the air. The physiological properties of marsh gas are similar to those of nitrogen or hydrogen. Fire damp is thus not a poison, but only a diluent to oxygen, and probably can only cause suffocation when it has less than 30 or 40 per cent. of air or 7 per cent. of oxygen mixed with it. Black damp, another suffocating gas found in mines, is usually said to be mostly carbon dioxide, but Dr. Haldane thinks there is no evidence for this, and that when undiluted it is chiefly nitrogen, seldom containing more than 20 per cent. of carbon dioxide. Choke damp is apparently another name for black damp, though it is sometimes used to designate after damp. Black damp, or choke damp, therefore, differs from air in the fact that it contains a few per cents. more carbon dioxide and a few per cents. less oxygen, the diminution of oxygen being, however, more marked than the increase of carbon dioxide. How is such air dangerous? What is the effect of increasing the carbon dioxide percentage in air, and what is the effect of diminishing the oxygen percentage? Dr. Haldane, with Dr. Lorrain Smith, undertook an investigation of the subject a short time ago. They found for carbon dioxide that at about 3 per cent. (as had formerly been found by Hermans) the respirations begin to be first appreciably increased in number and volume. At 5 per cent. this increase is quite evident. The panting increases as the percentage of carbon dioxide increases; and at about 10 or 11 per cent. is very violent, and usually accompanied by frontal headache, but no other very marked effect. At 18 per cent. there is confusion of mind after two minutes, as well as very violent panting and distress, which comes on in a few seconds. These results were about the same, whatever the percentage of oxygen, provided that not less than about 10 per cent. were present. For oxygen they found that a diminution of 8 or 9 per cent. made hardly any appreciable difference upon their breathing or in any other evident way. Beyond this there was some increase in the depth and frequency of the respirations, but not nearly of so marked a kind as in the case of air containing a correspondingly increased proportion of carbon dioxide. The person breathing air poor in oxygen may even get perfectly blue and corpse-like before he notices any distress. The dangerous percentage of oxygen is quite suddenly reached; and the first noticeable symptom may be loss of power in the limbs, and loss of one or more of the senses. A few breaths of air very poor in oxygen are sufficient to produce insensibility. Eight or nine breaths of air containing only 2 per cent. of oxygen caused Dr. Lorrain Smith to fall back senseless without having felt any distinct previous distress. Dr. Haldane emphasized the point that when the danger is from increase in the carbon dioxide percentage there is warning; when the danger is from deficiency of oxygen there may be little or no warning before the limbs and senses are paralyzed. The danger from choke damp and black damp seems to be of this sudden and dangerous kind. In the case of miners the lamp which they carry will, fortunately, give early warning of their danger, and keep them from walking into choke damp. An atmosphere in which the oxygen is diminished only about 3 per cent. will extinguish an ordinary light, whereas a diminution of 11 per cent. or more must be reached before there is any danger to life from deficiency of oxygen. White damp is another mixture of gases found in mines. The distinguishing character of white damp is that it may have fatal effects on a man and yet not extinguish a lamp. For this reason it is much feared. As to where it comes from and what it is, there is the usual lack of satisfactory information. One point, however, which seems to be clear is that it may originate from blasting with powder. Now, analysis shows that there are two intensely poisonous gases in the products of a gunpowder explosion—namely, carbon monoxide and sulphureted hydrogen. Moreover, the gases from "mining" powder, which is a cheap powder containing a low percentage of niter, contain far more carbon monoxide and sulphureted hydrogen than the gases of other powders. Carbon monoxide is a positive poison, and may produce death when present in the proportion of about 0·25 per cent. in air. Sulphureted hydrogen is still more deadly in its action. One-twentieth (0·5) per cent. has been shown to produce marked symptoms of poisoning in man; and one-tenth per cent. would almost certainly produce death if breathed for a short time.

Perhaps the most important of the suffocating damps found in mines is after damp, the mixture of gases which results from an explosion of fire damp or coal dust, or both, with air. After damp, if not too much diluted, extinguishes a lamp and causes death by suffocation. It is described in the evidence of Mr. Dickinson before the 1879 commission as having a "pungent, gaseous taste," and an irritating action on the eyes, and producing a feeling of malaise and torpor, which is a warning of imminent danger. Those who get too far into it lose the power over their legs, fall down, and are suffocated while in this helpless condition. Dr. Haldane has given a lot of attention to the composition of this gas, with the result that he has been led to dismiss the supposition that it consists chiefly of carbon dioxide, his conviction being that the usual cause of death from after damp is simply want of oxygen. Products, such as sulphureted hydrogen or carbon monoxide, can only be produced when the oxygen is used up; and when this is the case it does not much matter whether a little carbon monoxide or sulphureted hydrogen is present or not. That relatively large quantities of these gases are not present can be confidently inferred from the fact that after damp does not burn when mixed with air. If there were much carbonic oxide or sulphureted hydrogen there would certainly also be a large amount of free hydrogen and other explosive gases, which would burn in spite of their dilution with nitrogen. The practical question arising from these investigations is, can anything be done for the men who are in the pit during an explosion or fire to prevent the loss of their lives?

It seemed pretty clear to Dr. Haldane that if means could be provided to enable the men in a pit to keep alive in after damp for even a very short time, such as twenty minutes, they might all simply walk out to the neighborhood of the shafts, where there is usually abundance of fresh air, within a very few minutes. The direct way may be blocked by falls, but there is generally some way open, for the return air ways, at any rate, usually escape the explosion. For a man to live in after damp, he must first be supplied with oxygen. To keep him alive for an hour while exerting himself in making his escape would probably require about 60 or 70 liters of oxygen. This quantity can be compressed into a steel bottle of half liter, or less than a pint capacity. The oxygen so compressed would cost about 6d., and can be readily obtained. An apparatus for economically breathing this oxygen and for keeping out any poisonous substances present in after damp would also be necessary. Dr. Haldane gives a description of such an apparatus designed by himself.

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